COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

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October, 1944

Photo by H. R. Towle

Electric-arc welder at work on the final inside weld of a longitudinal seam

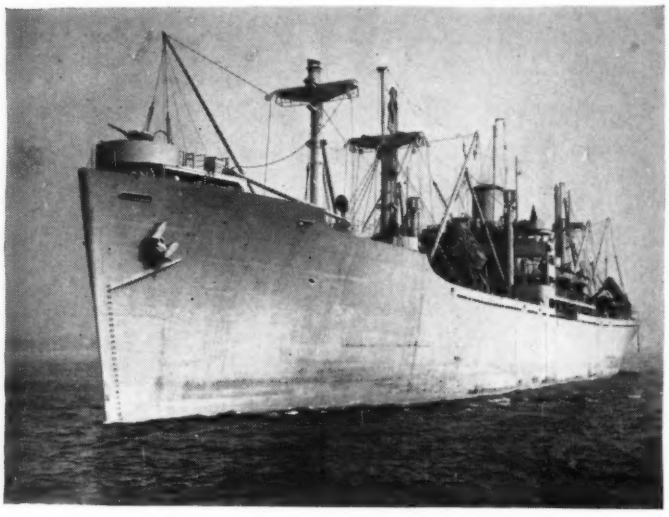
Control and Economics of Boiler Blowdown

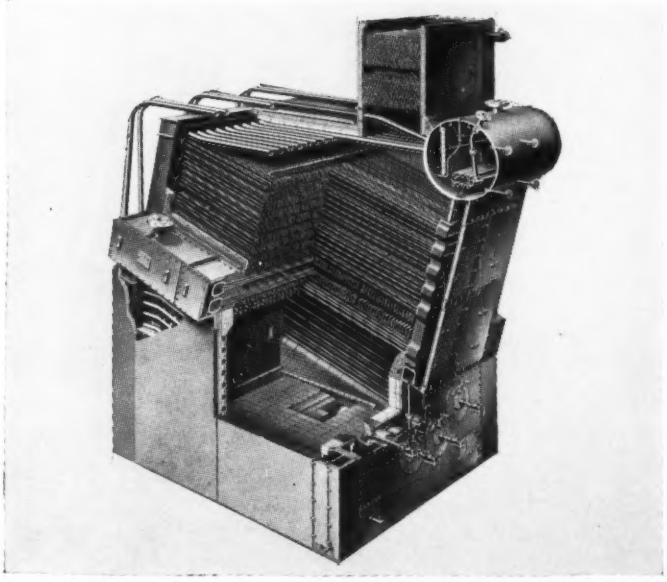
Practical Aspects of Boiler Feed Pump Material Selection

Measurement of Boiler Circulation by Means of Pitot Tubes

First Victory Ship to Encircle Globe

Wins high praise of Skipper and Crew





THE NEW YORK TIMES

The recent arrival of the Victory ship Poland Victory on the east coast marks the first circumnavigation of the globe by a vessel of that type. The ship's performance during this, its maiden voyage, brought forth high praise from operators and crew, the War Shipping Administration announced last week.

The Poland Victory's skipper, Capt. Leonard Duks, a veteran of thirty-eight years at sea, declared that the vessel had "fulfilled every promise that was made for this type of ship even when it was in the blueprint stage." He said he considered the Victory ship highly suitable for post-war cargo-carrying operations.

"This vessel," he said, "is not only speedy but economical of operation. Even now I can see how satisfying it will be in post-war days to be able to guarantee quick delivery of our bills of lading. If this Victory ship is a forerunner of what is to come there never need be any cause for worry about the future of the American merchant marine."

The Poland Victory was delivered from the Portland yard of the Oregon Shipbuilding Corporation to the Maritime Commission on March 19 of this year and has already covered more than 26,00[illegible]

The Poland Victory was one of the many Victory Ships completed ahead of schedule at the Portland yard of the Oregon Shipbuilding Corporation. Her recent arrival on the east coast marks the first circumnavigation of the globe by a vessel of her type and reflects further credit on the construction and equipment of these ships. Her performance during this, her maiden voyage, won high praise from her skipper and crew, according to a brief newspaper account reproduced above.

The boilers which supplied the steam to power the Poland Victory on her 26,000 mile voyage were designed and built by Combustion Engineering. To their ruggedness, dependability and easy steaming qualities must be attributed a considerable part of the credit for the Poland Victory's performance, characterized by her Captain as "speedy and economical." Such performance is being duplicated by hundreds of other vessels of our great Victory Fleet which are also powered by C-E Boilers. A-821A

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COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

VOLUME SIXTEEN NUMBER FOUR

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FOR OCTOBER 1944

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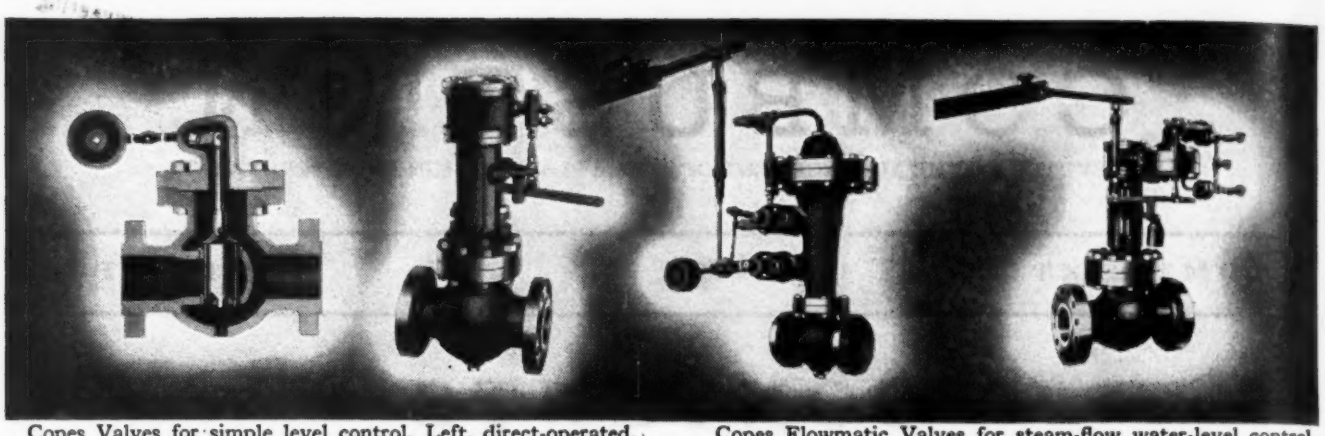

Copes Valves for simple level control. Left, direct-operated. Right, relay-operated.

Copes Flowmatic Valves for steam-flow water-level control. Left, direct-operated. Right, relay-operated.

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COPES

EDITORIAL

Package-Type Power Plants

Exigencies of war invariably leave their imprint on future practice. This was true following World War I and is even more likely to follow the present conflict, because of its greater magnitude.

In the field of power generation, the necessity for quickly rehabilitating devastated areas in the wake of advancing armies has been responsible for the evolution of the mobile power plant and the ordering of a vast number of so-called "package" power plants, which are being supplied under lend-lease. The former may be classed as an emergency measure but it is believed that the majority of the latter will find a permanent place in many of the rehabilitated small communities abroad.

These package power plants are built in several sizes, employing standardized design and adapted to burning a wide range in fuels, as well as to simplicity of operation. Success in meeting anticipated conditions may presage a substantial post-war export market both in Continental Europe and the Orient. They may even, perhaps with modifications, find a place in the industrial field at home.

British Fuel Conservation

The British Ministry of Fuel and Power has issued a progress report on results achieved by its fuel economy campaign undertaken more than two years ago as a war measure to eliminate waste in fuel utilization. While the report does not attempt to estimate the amount of fuel saved, it stresses the success of the campaign in making possible the meeting of vastly expanded fuel requirements with the limited fuel supplies available.

Visits to some twelve thousand plants by several hundred engineers revealed a surprisingly low average economy in fuel burning. Thus the opportunity for savings was great. Through the establishment of educational courses at various centers, wide distribution of fuel efficiency bulletins, the cooperation of many trade associations and assistance of the visiting engineers, the aggregate savings have been large. However, there appears to be room for still further improvement and the campaign is being carried forward.

The Fuel Efficiency Program inaugurated in this country some months ago under the sponsorship of the U. S. Bureau of Mines, as previously reviewed in these pages, is patterned largely after the British plan. However, it involves a much greater problem of organization due to the extent of the territory covered and the number of establishments to be contacted, in contrast with Britain whose area is comparable to that of New England. This fact has been largely responsible for delay in getting the plan into full operation.

While the production peak appears to have been reached and in some lines is receding, the fuel supply problem is still acute with little prospect of immediate betterment. In fact, Secretary Ickes reports strikes among coal mines during the week ending September 16 as responsible for the loss of 463,000 tons output, bringing the four weeks' loss to that date up to 1,159,684 tons; and further recurrent disturbances in fuel supply may be anticipated.

For this reason, even should the war in Europe terminate at an early date, there will still be need for wholehearted support to the Fuel Efficiency Program here.

Surplus Power Equipment

Despite preliminary steps that have been taken by the Government to formulate a policy for the disposal of surplus war material, the whole problem is still in an unsettled state, especially as concerns equipment in war plants to which the Government holds title.

As for power equipment, some will undoubtedly be held in reserve, much of it will be handled as an integral part of the plants concerned and be disposed of as such, and certain other classes of equipment, especially of smaller size, may find their way into the second-hand market. The last group is likely to include heating boilers of which many were installed in army camps and training centers that are likely to be abolished with the termination of hostilities. As for large steam-generating units, however, the cost of dismantling, reconditioning and adapting to new set-ups would appear to preclude them as serious competitors of new units. Moreover, the sale of firing equipment would, in general, be restricted to localities in which the particular type of fuel for which it had been designed is available.

Safety Movement Deep Rooted

The extent to which the safety movement has gained momentum in this country may be measured by the program of the Thirty-third National Safety Congress and Exposition held in Chicago on October third to fifth, inclusive. The printed program covered ninety-five pages, listing more than a hundred sessions in which nearly five hundred addresses, papers and panel discussions were scheduled; these in addition to an extensive exposition of safety devices. In magnitude it overshadowed any engineering meetings of recent years. Three Chicago hotels were required to accommodate the meeting. The papers, talks and discussions dealt with practically all the major branches of industry, transportation fields, utilities, the farm and the home.

At a time such as the present, when everyone's attention is focused on the war, and mounting casualty lists tend to ameliorate public reaction to loss of life and injury, such a meeting offers a testimonial to the deeply rooted conviction that prevention of accidents through planned safety is economically and humanely sound.

Control and Economics of BOILER BLOWDOWN

By WILLIAM L. NIELAND*

Following a general discussion of the necessity of blowdown and permissible solids content of boiler water, the author reviews methods of determining concentrations and shows the preferable location of blowdown connections for different types of boilers. He then discusses methods of control, including gravimetric determination, specific conductance, the chloride, sulphate, silica and alkalinity content and the applicability of each, concluding with the economics of control.

THE only reason for boiler blowdown, under normal operating conditions, is to lower the suspended and dissolved solids content of the boiler water. These solids are introduced by the feedwater and since the steam leaving the boilers is relatively pure, concentration of solids will develop in the boiler water. Excessive amounts of suspended solids will cause deposition of sludge and will, in addition, alter the surface tension of the boiler water which effect, in turn, may be severe enough to cause carryover. Excessive amounts of dissolved solids have the same deleterious effects as suspended solids and, in addition, when the solubility of the salts present is exceeded, scale will be deposited.

The American Boiler Manufacturer's Association in its standard guarantee of steam purity stipulates the following limits for the solids content of a boiler water:

Boiler Pressure, Psi Gage	Total Solids, Ppm
0– 300	3500
301– 450	3000
451– 600	2500
601– 750	2000
751– 900	1250
1001–1500	1000

These recommended limits for solids are not necessarily exactly applicable to each individual case. Rather, they are limits of a general nature—providing a good starting point from which to vary solids in accordance with the specific needs of the particular plant.

The solids content of the boiler water is only one factor controlling boiler blowdown. In many cases blowdown is based on limiting the silica content of the boiler water below a certain value. For example, in one plant it may have been determined that 100 ppm of silica, as SiO_2, is the maximum that can be tolerated in the boiler water without the deposition of silicious scale. The feedwater contains 10 ppm of silica, as SiO_2, and 125 ppm of total solids. To limit the silica content of the boiler water to 100 ppm would necessitate maintaining cycles of concentration no greater than ten which is equivalent to a 10 per cent rate of blowdown. Therefore, in this case, the boiler-water total solids content would be 1250 ppm even though A.B.M.A. limits might permit much higher solids. A casual investigation of such a plant, without an investigation of the silica problem, might result in a decision to reduce the 10 per cent rate of blowdown because boiler-water solids are only 1250 ppm. Such a decision would result in serious scale difficulties. It is necessary in setting boiler-water limits to investigate thoroughly every factor bearing on the situation.

In the example cited, silica was the limiting factor governing blowdown. In another plant alkalinity or suspended solids may be the limiting factor. The two objectives of pure steam and clean boiler-heating surfaces govern the boiler-water limits which are established.

Aside from the chemical balances maintained in the boiler water there are many mechanical factors which influence the amount of total solids that can be carried safely. These include boiler design, boiler rating, water level, and load characteristics—whether relatively constant or subject to extremely rapid variation.

It can readily be seen that a boiler containing a relatively small volume of water and producing 60,000 lb of steam per hour will be more sensitive with respect to carryover, all other things being equal, than a boiler generating the same amount of steam but containing two or three times as much water.

Where the plant load changes rapidly in a very short period the water level in the boiler may rise and fall rapidly and the tendency toward carryover will be far greater than in a plant where the load increases and decreases gradually.

It is because of these factors that it is possible for one plant to maintain suspended and dissolved solids below their critical values by employing one bottom blow per boiler per day while another plant using the same raw water and producing the same amount of steam per day might require one bottom blow per boiler per hour. It would be to the advantage of the latter plant to install continuous blowdown with heat recovery and thereby effect considerable economy in operation.

Location of Continuous Blowdown Line

Location of the continuous blowdown line depends upon boiler design. To illustrate: consider two plants that have installed 4-drum boilers. Plant A's boilers are of the four-drum, bent-tube type with water-circulating tubes connecting the upper rear and middle drums. Plant B's boilers do not have water-circulating tubes

* Chemical Engineer, W. H. & L. D. Betz, Philadelphia, Pa.

connecting the rear and middle drums. In the former circulation is such that the continuous blowdown line can be connected to either the rear or the center drum. However, in the latter the circulation is such that the continuous blowdown line can be connected to the front or to the center drum. If in this unit the continuous blowdown line were connected to the rear drum, feedwater rather than concentrated boiler water would be blown out.

In a three-drum low-head unit, or one of similar design, the continuous blowdown line is normally installed in the steam take-off drum, as illustrated in the arrangement shown in Fig. 1.

In the straight-tube inclined-drum type of boiler it is of the utmost importance to install the continuous blowdown line in the proper location. Some of the earlier units of this type, many of which are still in service, were provided with a small so-called "mud drum", or tube, inside the main drum or drums. The feedwater enters the boiler through a pipe which passes into the front end of this internal drum and then flows slowly back along the bottom, depositing dirt and sediment therein. As the water becomes heated, it rises and flows forward along the top of the mud drum and out at the front end. From here the circulation is toward the back of the boiler, down the rear water leg, forward through the tubes and up the front water leg into the main steam drum of the boiler.

This internal mud drum is equipped with a blowdown line and should be blown down once or twice per day. Many plants installed continuous blowdown at this

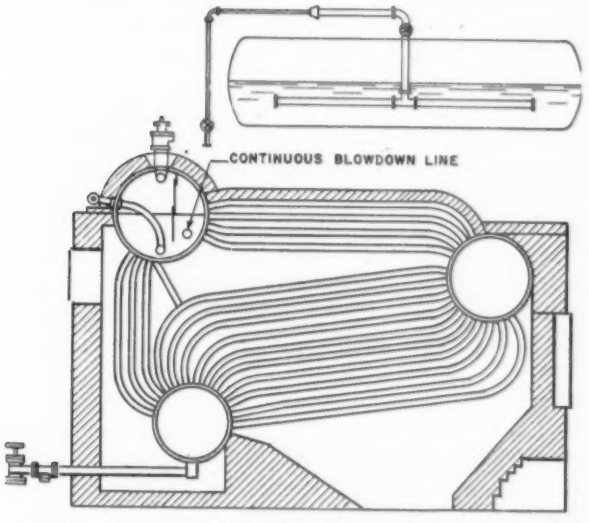


Fig. 1—Showing usual location of continuous blowoff line with low-head bent-tube boiler

point. This is incorrect because by so doing the feedwater, rather than boiler water, is blown down. The proper place for the continuous blowdown line is in the front section of the main steam drum directly over the "up-comers." It is at this point that the boiler water is the most concentrated and naturally is the point at which the continuous blowdown line should be installed.

In the longitudinal two-drum and three-drum type boiler having sinuous headers, it is necessary to install the continuous blowdown line in each drum unless there are installed equalizing tubes connecting the drums. If such tubes are not installed, it is quite possible to have considerable variation in the chemical concentration of the water in each drum. If instead of sinuous headers, the boiler has box headers, it is necessary to install a continuous blowdown line in one drum only.

Fig. 2 shows one method of installing a continuous blowdown line in a horizontal return-tubular boiler. The shell of the boiler should be tapped and fitted in an approved manner, one that will meet the requirements of the boiler insurance company. A pipe, the size of

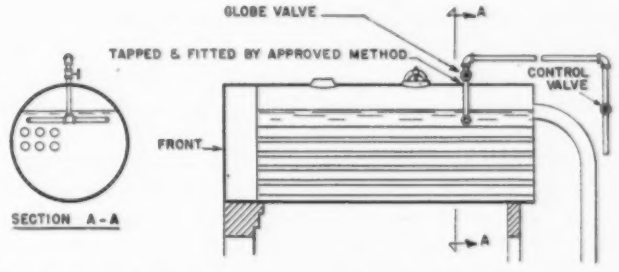


Fig. 2—Location of continuous blowdown with horizontal return-tubular boiler

which is dependent on the required amount of blowdown and equipped with a globe valve just outside of the boiler shell, should be inserted through this opening and extend down inside of the boiler to a point about two inches below the low water level of the boiler. At this point a tee should be inserted in the line and branches extended to the right and left. These branch pipes should be drilled with $^1/_4$-in. holes facing upward and each end should then be capped and drilled for a $^1/_4$-in. hole.

The first globe valve outside the boiler serves only as an emergency stop valve. Farther along the line, at a point within easy access of the operator, a control valve is inserted. This valve should be of the flow-control type and marked for various settings. It is with this valve that the rate of continuous blowdown is controlled. By setting this valve at the various markings, known quantities of water are removed from the boiler, the amount removed being determined by the concentration it is desired to carry.

Methods of Controlling Blowdown

Once the optimum boiler-water concentration has been determined it can be controlled by several methods. In addition, one of these methods (chloride) enables the operator to calculate accurately the per cent blowdown. This is of particular value where no blowdown meters are installed and serves as a check where such meters are used.

Among the factors that may be used for blowdown control are the total solids content of the boiler water (determined gravimetrically), the dissolved solids as measured by specific conductance, the chloride, sulphate, silica and alkalinity content of the boiler water.

TOTAL SOLIDS—Determination of the total solids content of the boiler water provides an excellent control over blowdown, but while usually applicable from a technical standpoint, it is rarely employed as the analysis requires too much time and is too difficult for routine control. There are objections to the use of the total solids tests for

calculation of the rate of blowdown. A comparison of the total solids content of the boiler water with the total solids content of the boiler feedwater will not necessarily provide an accurate measure of the concentration that has taken place within the boiler.

The first reason why inaccuracies would be introduced into calculation of the rate of blowdown is that although the solids present in the feedwater are usually in dissolved form, under the influence of treatment, heat and concentration in the boiler, the feedwater hardness is precipitated. The calcium and magnesium salts which were in solution in the feedwater are now present in the boiler in suspended form. Unless the method of sampling the boiler water is such as to insure the same amount of suspended solids present in the sample as is actually present in the average boiler water, no blowdown calculation will be accurate. Since there is a tendency for heavier suspended solids to settle to the lower part of the boiler, the sampling point used may provide a boiler water sample deficient in suspended solids which, of course, will affect the total solids determination, making the calculated rate of blowdown erroneously high.

A second cause for error is the loss of carbon dioxide with the steam. Reference is not made to the loss of free carbon dioxide which may be present in the feedwater. Rather, we are concerned with bicarbonate or carbonate ions present in the dissolved form in the feedwater which under the influence of heat in the boiler, break down and release free carbon dioxide with the steam. The mechanism of this reaction is as follows:

$$\underset{\text{Sodium Bicarbonate}}{2NaHCO_3} + \Delta = \underset{\text{Sodium Carbonate}}{Na_2CO} + \underset{\text{Water}}{H_2O} + \underset{\text{Carbon Dioxide}}{CO_2}$$

$$\underset{\text{Sodium Carbonate}}{Na_2CO_3} + \Delta + \underset{\text{Water}}{H_2O} = \underset{\text{Sodium Hydroxide}}{2NaOH} + \underset{\text{Carbon Dioxide}}{CO_2}$$

In these reactions carbon dioxide is evolved with the steam and is not included in the determination of the total solids content of the boiler water, whereas it has been measured in a determination of feedwater solids. Although in cases of low feedwater alkalinity the influence of this effect may be negligible, where feedwater alkalinity is higher an error will be introduced and tend to provide an erroneously high calculated rate of blowdown.

A third factor influencing calculation of the rate of blowdown from the comparative total solids content of the feedwater and boiler water is the effect of internal chemical treatment. In many cases, all internal chemical treatment will be introduced into the boilers directly by means of chemical pumps. Where feedwater hardness is relatively high, the solids introduced by chemical treatment may be almost as great as the feedwater solids. A large source of error is thereby introduced since the feedwater sample will not contain the internal chemical treatment while the boiler-water sample will contain the treatment either in the dissolved or suspended form. Even in plants where chemical treatment is not fed directly to the boiler, it is customary to feed at least a portion of the treatment in "shot" fashion in order to avoid premature reaction in the feed line and consequent feed-line deposits. It is obviously impossible under such circumstances to obtain a feedwater sample which would provide an accurate basis for calculation of the rate of blowdown.

DISSOLVED SOLIDS—Determination of the specific conductance of a boiler water will provide an accurate measure of the dissolved solids content and usually it can be applied to blowdown control with considerable advantage. However, calculation of the rate of blowdown on the basis of the relative specific conductance of the feedwater and boiler water is not technically correct. Not only will specific conductance be affected by loss of carbon dioxide with the steam and the solids introduced by internal chemical treatment, but the specific conductance of dilute solutions such as feedwater and concentrated solutions such as boiler water cannot be compared directly. The specific conductance of any sample is caused by ionization of the various salts present in the sample. In dilute solutions, ionization increases and greater specific conductance results. In more concentrated solutions, ionization is repressed and specific conductance decreases per part of salt present. This effect is illustrated by the fact that the solids content of very dilute solutions such as condensate may be calculated by using a factor of 0.5 to 0.6 ppm of dissolved solids per micromho of specific conductance. In more concentrated solutions, such as boiler water, an average value is approximately 0.76 ppm dissolved solids per micromho of specific conductance.

Therefore, calculation of the rate of blowdown by measurement of specific conductance is not technically correct. However, the use of specific conductance for blowdown control is usually a very reliable and accurate method, once specific conductance values have been properly correlated with the dissolved solids content of the boiler water and after proper specific conductance limits have been established, considering all possible factors limiting blowdown such as the suspended solids, silica and alkalinity content of the boiler water.

SULPHATE, SILICA AND ALKALINITY—Under certain circumstances, the sulphate, silica and alkalinity content of the boiler water can be used for blowdown control where they are factors which, in that particular case, limit the boiler-water concentrations that may be safely tolerated. Usually, these determinations are not suitable for calculation of the rate of blowdown; since both sulphate and silica may be removed from solution as scale, the use of sodium sulphite will increase the sulphate content of the boiler water, and alkalinity is usually affected by either variable softener balances or by the internal treatment employed. All these conditions prevent accurate determination of the relative feedwater and boiler-water concentrations which is the basis for calculation of the rate of blowdown.

CHLORIDE—The chloride determination can be used not only for blowdown control but it is also suitable for the accurate calculation of the rate of blowdown provided the chloride concentration of the feedwater is of sufficient magnitude to permit accurate measurement by this test. Since chloride is not subject to precipitation in the boiler water, the determination of the relative chloride concentration of the feedwater and boiler water provides the most accurate basis for calculation of the rate of blowdown. Therefore, the per cent blowdown can be calculated by the following formula:

$$\frac{\text{Chloride in feedwater}}{\text{Chloride in boiler water}} \times 100 = \%\ \text{blowdown}$$

For those who desire an algebraic proof of the foregoing formula this is illustrated as follows:

Let x = quantity of feedwater
y = quantity of blowdown water
a = chloride concentration in feedwater
b = chloride concentration in boiler water
k = per cent blowdown

Therefore, by definition:

$$k = \frac{100y}{x}$$

We wish to prove that:

$$k = \frac{100a}{b}$$

PROOF.—Under equilibrium conditions the total chlorides entering the boiler must equal the total chlorides leaving the boiler; therefore,

$$xa = yb$$

Multiplying both sides of the equation by $100/xb$, we obtain

$$\frac{100a}{b} = \frac{100y}{x}$$

We know by definition above that

$$k = \frac{100y}{x}$$

Therefore,

$$K = \frac{100a}{b} \text{ or } \% \text{ blowdown} = \frac{\text{chloride in feedwater} \times 100}{\text{chloride in boiler water}}$$

The following facts should be kept in mind when considering blowdown figures that are based on the foregoing formula.

1. The percentage blowdown includes any water leaving the boiler. It therefore includes any carryover of dissolved solids with the steam.

2. The feedwater determination must be an average. A spot sample may be misleading, particularly if feedwater chlorides vary to any extent.

3. Where a zeolite softener is used, complete rinsing following regeneration must be employed, otherwise the feedwater chloride content will be erroneously high.

The chloride test is unsuitable for this calculation only in those cases where the feedwater chloride is quite low, such as 0.5 to 1.0 ppm. In this range a slight analytical error in determining feedwater chloride content will cause an appreciable error in the calculated rate of blowdown.

TABLE 1—TYPICAL CALCULATIONS ON SAVINGS POSSIBLE THROUGH REDUCTION IN BLOWDOWN

Basis—1 day

Evaporation = 5,000,000 lb steam
Boiler pressure = 200 psi gage
Feedwater temperature = 200 F (live steam used)
Makeup water temperature = 60 F
Present rate of blowdown = 5.0%
Optimum rate of blowdown = 2.0%
Boiler efficiency = 75%
Fuel = Coal at 14,000 Btu/lb, $5.00 per ton delivered and fired
Feedwater = Steam plus blowdown
Feedwater at 5.0% blowdown = 5,263,000 lb
Feedwater at 2.0% blowdown = 5,102,000 lb

Saving in boiler feedwater = 161,000 lb
Heat of liquid at boiler pressure, Btu/lb = 362
Heat of liquid at 60 F, Btu/lb = 28

Heat saving, Btu/lb = 334
Total heat saving = 161,000 lb × 334 Btu/lb = 53,774,000 Btu
At boiler efficiency of 75% there is actually utilized 14,000 Btu/lb × 0.75 = 10,500 Btu/lb of coal

$$\text{Coal savings} = \frac{53{,}774{,}000 \text{ Btu}}{10{,}500 \text{ Btu/lb coal}} = 5121 \text{ lb}$$

$$\text{Daily savings} = \frac{5121}{2000} \text{ lb coal} \times \$5.00/\text{ton} = \$12.80$$

It is to the benefit of any plant to maintain consistently boiler-water concentrations at the optimum value. Let it be assumed that due to improper internal treatment and control a 5.0 per cent rate of blowdown is being maintained while with proper internal treatment and control this rate of blowdown could be reduced to 2.0 per cent. Calculations showing the resultant savings are shown in Table 1. It can be noted that a daily savings of $12.80 results in this instance, simply through the use of a system of chemical treatment which permits a lower boiler blowdown.

In many cases, such results can be achieved simply by the application of proper internal chemical treatment. The suspended solids content of a boiler water is one of the chief factors causing carryover of boiler-water solids with steam. If proper internal treatment is employed to adsorb or coagulate the suspended boiler-water precipitates, it is usually possible to overcome the tendency for these precipitates to stabilize boiler-water foam. Higher boiler-water concentrations and reduced blowdown can then be maintained with resulting savings in the fuel.

In addition, the use of external softening such as the lime-soda or zeolite type can frequently be justified because of the lower feedwater solids or hardness resulting from the use of such equipment. With lower feedwater hardness or solids content, a reduction in boiler blowdown may usually be made and, in some cases, the installation of external softening equipment can be justified by this one point alone.

Where continuous blowdown is employed, it is advantageous to install heat-exchange equipment. Whether

TABLE 2—TYPICAL CALCULATIONS ON SAVINGS POSSIBLE THROUGH USE OF HEAT RECOVERY ON CONTINUOUS BLOWDOWN

Basis—1 day

Evaporation = 5,000,000 lb steam
Boiler pressure = 200 psi gage
Feedwater temperature = 200 F (live steam used)
Makeup water temperature = 60 F
Rate of blowdown = 5.0%
Boiler efficiency = 75%
Fuel = Coal at 14,000 Btu/lb, $5.00 per ton delivered and fired
Feedwater = Steam plus blowdown
Feedwater = $\frac{5{,}000{,}000 \text{ lb}}{0.95}$ = 5,263,000 lb
Blowdown = 263,000 lb
Employing a flash tank at 5 psi gage, the quantity of 5-psi steam available may be calculated from the formula:

$$\% \text{ flashed steam} = \frac{H_b - H_f}{V_f} \times 100$$

where H_b = Heat of liquid at boiler pressure in Btu/lb
H_f = Heat of liquid at flash pressure in Btu/lb
V_f = Latent heat of vaporization at flash pressure in Btu/lb

$$\% \text{ flashed steam} = \frac{362 - 196}{960} \times 100 = 17.3$$

Flashed steam available at 5 psi = 263,000 lb × 0.173 = 45,500 lb
Total heat of flashed steam at 5 psi = 1156 Btu/lb
Heat savings in flashed steam = 1156 Btu/lb − 28 Btu/lb × 45,500 lb = 51,324,000 Btu

The drain water from the flash tank is passed through the heat-exchanger and thence to the sewer. It is assumed that the temperature of the water leaving the exchanger is 20 F above the incoming makeup water or 80 F.

Heat of liquid at 80 F = 48 Btu/lb
Heat of liquid at 5 psi = 196 Btu/lb
Heat recovery = 148 Btu/lb

Heat savings from heat-exchanger = 263,000 lb × 0.827 × 148 Btu/lb = 32,190,000 Btu
Total heat savings = 51,324,000 Btu plus 32,190,000 Btu = 83,514,000 Btu
At a boiler efficiency of 75 per cent there is actually utilized 14,000 Btu/lb × 0.75 = 10,500 Btu/lb coal

$$\text{Coal savings} = \frac{83{,}514{,}000 \text{ Btu}}{10{,}500 \text{ Btu/lb coal}} = 7954 \text{ lb}$$

$$\text{Daily savings} = \frac{7954 \text{ lb coal}}{2000} \times \$5.00/\text{ton coal} = \$19.90$$

a heat-exchanger and/or a flash tank is employed depends upon the plant heat cycle.

The flash tank is constructed of steel plate, fabricated and designed in accordance with the A.S.M.E. Boiler Code for Unfired Pressure Vessels. It is drained by a float-operated, balanced valve. A gage glass and a high-level water line on the flash tank shows whether or not the flash tank is being properly drained. A relief valve is supplied having the capacity to relieve, at the pressure for which the tank is designed, as much water or steam as will be generated from the water passing through the control blowoff valves when all are fully opened.

The flash tank is suitably baffled and is so proportioned that the flashed steam will contain very little moisture and will be of as good quality as steam obtained from the boilers.

the heater while the unflashed or drain water from the flash tank is sent through a heat-exchanger. This drain water contains an appreciable amount of heat which is given up to the incoming raw water. The temperature of the waste water leaving a well-designed heat-exchanger will be 10 to 20 deg above that of the incoming raw water.

In Fig. 4 there is employed a high-pressure and a low-pressure flash tank in conjunction with a heat-exchanger. In this case the drain water from the high-pressure flash tank is passed to the low-pressure flash tank at which point additional flashing takes place. From this point on the setup is the same as described for Fig. 3.

It would be of interest to calculate the savings resulting from the installation of the type equipment shown in Fig. 3. These calculations are listed in Table 2.

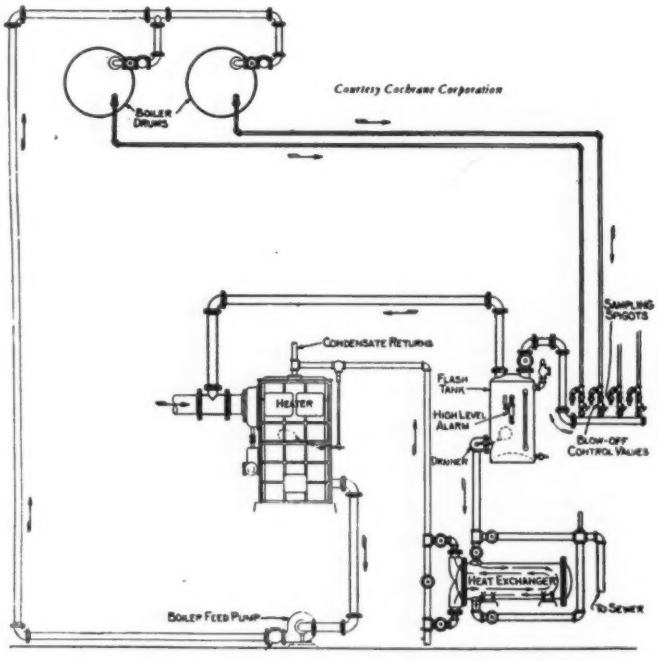


Fig. 3—Single flash tank and heat-exchanger

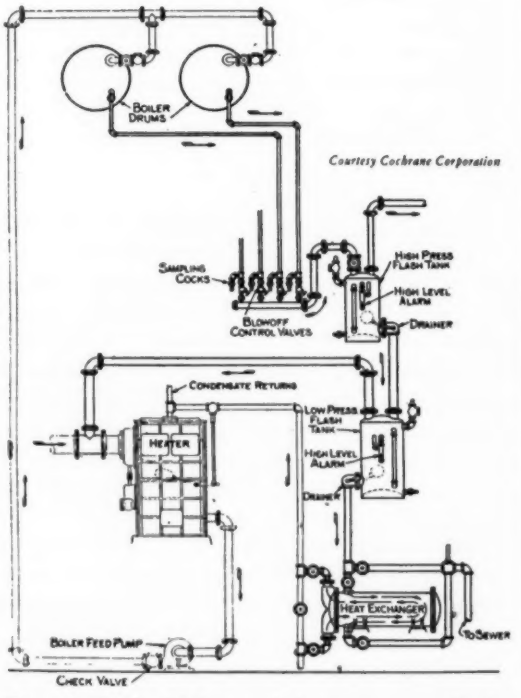


Fig. 4—Both high- and low-pressure flash tanks in conjunction with heat-exchanger

The heat-exchanger usually employed is of the two-pass counterflow design, with the water to be heated inside the U-tubes and the blowoff water outside. These U-tubes are generally constructed of copper. Longitudinal and cross baffles insure rapid flow of the boiler water around the tubes as required for a high degree of heat transfer.

Figs. 3 and 4 show two typical installations in which a heat exchanger and flash tanks are utilized. In Fig. 3 the blowoff lines from the boilers run directly to a pipe manifold located conveniently for the operation of the control valve and for taking a sample of blowoff water. This manifold is connected to the flash tank, which may be located at any suitable elevation.

A portion of the boiler water entering the flash tank is flashed to steam, the amount flashed depending on the boiler pressure and on the pressure at which the flash tank operates. The resulting flashed steam is passed to

To summarize, the control and economics of boiler blowdown are subjects of highest importance to the efficient and economical operation of a power plant. The control of the boiler blowdown is of utmost importance to the maintenance of clean boiler heating surfaces and to the production of a pure, dry steam. The chemical tests used for the control of blowdown, as well as the control limits, should be established only after a detailed study of all chemical and mechanical factors bearing on the problem.

The economics of blowdown also requires careful study. Material savings in fuel and water consumption may be made either by the application of proper chemical treatment methods or by the installation of heat-recovery equipment. The entire subject of blowdown is of sufficient importance to justify in every case a detailed study of this important problem by a competent water-treatment engineer.

Practical Aspects of Boiler Feed Pump Material Selection

L. J. DAWSON

Field Engineer, Cameron Pump Div., Ingersoll-Rand Co.

The author reviews the mechanical properties of materials suitable for boiler feed pump construction, especially those intended for high-pressure service; also the chemical stability of these materials. He discusses the phenomenon of corrosion-erosion and its prevention, and concludes that in selecting a pump maintenance and availability are factors that outweigh considerations of first cost.

IN THE selection of materials for central-station boiler feed pumps, there are several important considerations. The first of these is the mechanical properties of the material. Obviously, the pump cannot be constructed of materials that may fail structurally however desirable their other properties. Closely tied in with structural strength is hardness, which in many instances is the determining factor in service life.

One must also consider the chemical stability of the material in the liquid being pumped. It has been brought forcibly to the fore that boiler feedwater is active chemically and in many cases may be considered a strong solvent. The theory that the purer the water, the less corrosive has been demonstrated a fallacy.

Lastly, one must consider the cost angle. This aspect must be subdivided into original cost and upkeep, the sum of which will determine the overall cost of the equipment for a period of years.

Mechanical Properties

In the stress and temperature ranges encountered in high-pressure installations, some form of steel is the only acceptable material for many pump parts, and in particular the casing. In the moderate-pressure range, the choice is broadened to include carbon steel, alloy steel, straight or alloy cast iron and bronze.

With the possible exception of the shaft, the use of alloy steel is to improve the chemical stability rather than the physical properties. Sufficient strength and/or hardness can be obtained from straight carbon steels either in the natural or the heat-treated condition. Where strength requirements are secondary to other factors, cast iron and bronze offer some advantages. The ease of casting and machining the cast irons has led to their universal use in bearing bodies and similar low-stress applications. Designs for iron parts can be more complicated without introducing a foundry problem. The bronzes have enjoyed widespread usage in impellers and wearing parts, but here again the advantage over cast iron is mainly one of chemical stability.

The increase of pressure per stage has focused attention on the hardness of wearing parts materials. Increased stage pressures mean increased leakage velocities, with consequent increased erosion tendencies. The part may be hardened throughout or have a hardened surface only.

Stainless steels of the straight chrome or chrome-moly type come in the former category, as they are not amenable to surface hardening. Heat-treated stainless steels range from 250 to 500 Brinell, with the most useful range from 300 to 400. The higher hardness heat treatments make these steels particularly susceptible to cracking from thermal shock, a condition which puts definite limitations on the use of stainless steels for shaft sleeve materials.

Carburized or nitrided materials have the advantage of an extremely hard surface (over 600 Brinell) on a tough core. On the other side of the ledger, these materials have no corrosion resistance, and this shortcoming has practically eliminated these materials from usage on central-station feed pumps except for shaft sleeves. Here, the extreme hardness advantage more than offsets the lack of corrosion resistance, and the tough core eliminates splitting from thermal shocks. A nitrided sleeve is the only material which can be heated to a red heat without losing hardness, a condition which only too often prevails when improper packing adjustment shuts off stuffing-box leakage. The subsequent thermal shock when leakage is re-established has caused the splitting of many stainless sleeves which were hardened throughout.

Chemical Stability

The chemical stability of the pump part material is directly related to the water handled by the unit. The terms "chemical stability" and "corrosion resistance" are synonymous, and for all internal parts, water may be considered as a corrodant. The pH range encountered in modern central-station feedwater is roughly 6.0 to 9.0, with total solids less than 5 ppm unless recirculation of boiler salines is practiced. It is an exacting task to determine accurately the pH of unbuffered waters, and only continuous-sampling electrometric apparatus is acceptable.

The pH of unbuffered waters is affected by the slightest addition of salts or absorption of gases such as CO_2 or NH_3. With unbuffered waters, pH fails to be the criterion of suitability of materials, and supplementary factors of temperature and total solids must be considered.

For buffered waters, the effect of pH on materials is definitely established. Waters of high hydrogen-ion concentration, and hence low pH, are corrosive to iron and straight carbon steel but do not attack bronze or

stainless steels. Waters of high hydroxyl-ion concentration and low hydrogen-ion concentration, with attendant high pH, attack bronze but do not attack iron and plain or stainless steels. In the range of pH values just above and below neutral, neither bronzes, steels nor irons are attacked to any appreciable extent.

Unbuffered waters, on the other hand, are definitely corrosive to iron and carbon steel. This is true even though the pH range of such waters is only 6 to 9. To have a water with a pH value above 9 or under 6, the total solids must be increased to a point where the water is no longer unbuffered.

Unbuffered water corrosion takes the form of dissolving the iron to form ferrous hydroxide. If the water is stagnant, it will eventually become saturated with iron salts and attack will cease. In the case of a pump through which fresh condensate is continuously passing, the water has no chance to become saturated and corrosive attack is progressive. This is especially evident in areas subject to high velocity water where the corrosion products are swept from the surface as soon as formed. When the protective coating of corrosion products is removed, a fresh surface is exposed to attack, and corrosion is progressive unto destruction. When corrosion products are washed away as soon as formed, the type of attack is called "corrosion-erosion." Figs. 1 and 2 show typical cases of corrosion-erosion.

The importance of the corrosion aspect in cases of corrosion-erosion failures can be demonstrated by removing the corrosion aspect while leaving the erosion set-up unchanged. As an example, straight carbon steel diffusors in a pump handling unbuffered water will fail by corrosion-erosion of the vanes in a very short period of service. Substitution of stainless steel of substantially the same hardness will eliminate corrosion-erosion of the vanes. The water velocity, and hence the erosive tendency, has not been changed by this change in materials; what has changed is the stability of the surface layer. With a corrosion-resistant material, the mechanical properties of the surface layer are not impaired by corrosion and hence progressive corrosion-erosion does not take place.

Consider also the case of a bronze impeller mounted on a carbon-steel shaft. If leakage occurs under the hub, the carbon-steel shaft will be water-cut due to corrosion-erosion, whereas the bore of the bronze impeller will not be affected. Here is plainly a case where corrosion resistance means more than erosion resistance, for the bronze is softer than the steel.

Fig. 1—Corrosion-erosion of carbon-steel shaft

In general, it may be stated that straight carbon steels are the worst offenders in corrosion-erosion by unbuffered waters. Cast iron has more resistance but is definitely not immune. For complete immunity one must resort to chemically stable materials such as the chrome or chrome-nickel alloys.

Chemical stability also influences the life of shafts subject to repeated bending stresses. It has been established by laboratory experiments that shaft surface condition has a pronounced effect on the fatigue limit. Surface roughness or pitting resulting from corrosion produces points of high stress concentration. These points eventually develop fissures in planes at right angles to the shaft centerline, and these fissures grow in area with each stress cycle. Eventually the cross-sectional area of the shaft is reduced to such an extent that failure from torsional stress results.

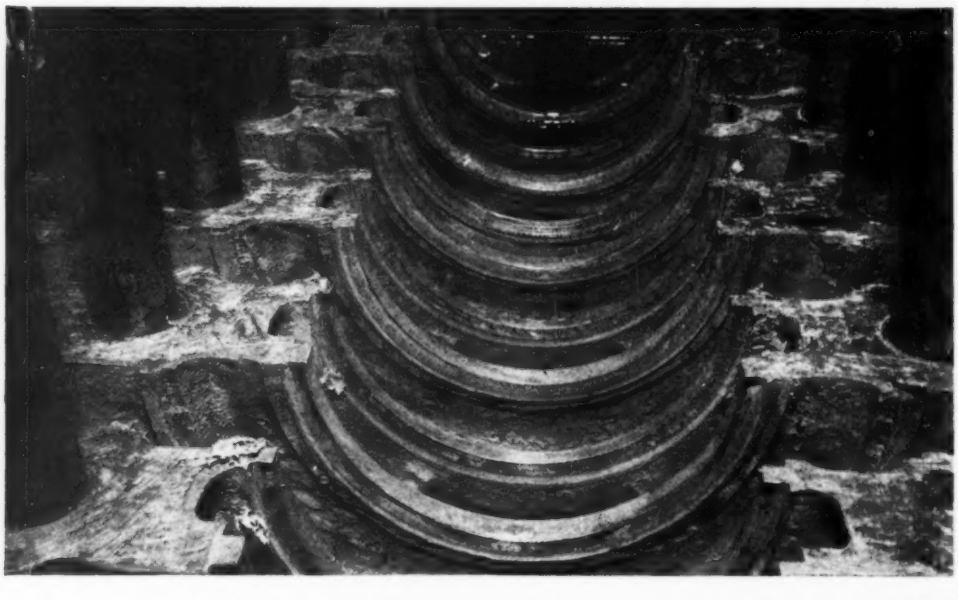


Fig. 2—Corrosion-erosion of interstage diaphragm side walls of multi-stage boiler feed pump

This type of failure is not common on boiler feed pumps due to the low bending stresses inherent with multi-stage design, and also to the fact that unbuffered waters are such poor electrolytes that galvanic corrosion between shafts and hubs is nil. Corrosion fatigue is, however, a serious problem on single-stage service water and circulating pumps.

The use of stainless steel parts has introduced the problems of corrosion from concentration cells and differential aeration. The straight chrome steels are particularly susceptible to the latter type, and special attention must be paid to parts coming in contact with packing containing organic material. Most power plant operators have already encountered this phenomenon on valve stems. Proper selection of packings can materially reduce this action. An alternative is to plate the area under the packing.

Cost Factors

The first cost of machinery is often a deceptive figure. This is particularly true of a boiler feed pump which is expected to last from 10 to 25 years. As the expense of a complete overhaul of this type of equipment will amount to 10 to 20 per cent of the original price for the complete pump, it will not require many such overhauls to double the investment in the unit. It stands to reason that any improvement of pump materials which will decrease the number of overhauls, even though the original price is somewhat increased, will result in a saving over a period of years.

One must also consider those factors which are difficult to gage monetarily, namely, dependability and peace of mind. Dependability directly affects availability, which is just as important on a feed pump as it is with the boiler or turbine. Peace of mind is that glorious thing that only too few plant superintendents enjoy. Knowledge that the feed pump equipment is the most dependable that money can buy is the best sedative.

Finally, the salvage and reconstruction possibilities of the parts materials should be given consideration. Metals which cannot be successfully welded or brazed should be avoided unless the part is in a location where such work is not to be expected. This consideration applies more to the permanent parts of the pump, such as the casing or impellers. Only in emergency cases can salvage of inexpensive wearing parts be justified.

In conclusion, the fact should be stressed that the best materials are the cheapest in the long run. The purchaser of feed-pump equipment should lean heavily on the recommendations of the pump manufacturer, as his experiences in the field have established his recommendations.

Swiss Development of the Gas Turbine for Power

At present when there is widespread interest and much active development work going on with combustion turbines in this country, it is fitting to review the comments of a pioneer Swiss company in this field, as contained in the latest issue of *The Brown Boveri Review*. Pointing out that abnormal conditions due to the war have deferred the completion of several installations previously started, the statement is made that research has continued in three principal directions: (1) further development of the combustion turbine for special applications where operating conditions are favorable; (2) installations with which the gas turbine in its simplest form may be employed and where preheaters or recuperators of suitable proportions enable high efficiencies to be attained; and (3) plants of greater output where the generator and the compressors are driven by separate gas turbines, the compressors being of the centrifugal or radial-flow type, if desired, and their power consumption kept low by cooling.

As an example of the first type of application, a proposal is cited for an industrial plant in which a rich CO_2 gas is available from metallurgical furnaces. After cooling, the gases are supplied to a gas turbine which, with correspondingly proportioned recuperators, attains a thermal efficiency of 26 per cent and delivers a net output of 900 kw. The exhaust of the turbine at a temperature of 356 F is employed to dry casting moulds. Because of the importance of high efficiency at partial loads in this case two gas turbines are proposed, one for driving the generator at constant speed and the other for variable-speed drive of the compressor.

It is observed that the permissible size of the recuperator, upon which high overall efficiency depends, is governed by economic considerations in which the size of plant and load conditions are factors. Apart from the question of fuel, the prospects of the simplest form of combustion turbine depend, therefore, on the success attending the endeavor to evolve less expensive and more suitable recuperators. Every effort has been made to solve this problem.

Installations of over 5000 kw will comprise several machine sets with compressor and turbine split up into two or more pressure stages. The air will preferably be cooled between the pressure stages and the driving gases reheated to approximately 1100 F between the turbine stages through the interposition of a further combustion chamber. Where ratings of about 10,000 kw are considered, it is contended that such a gas turbine plant would surpass high-class steam installations on the score of economy.

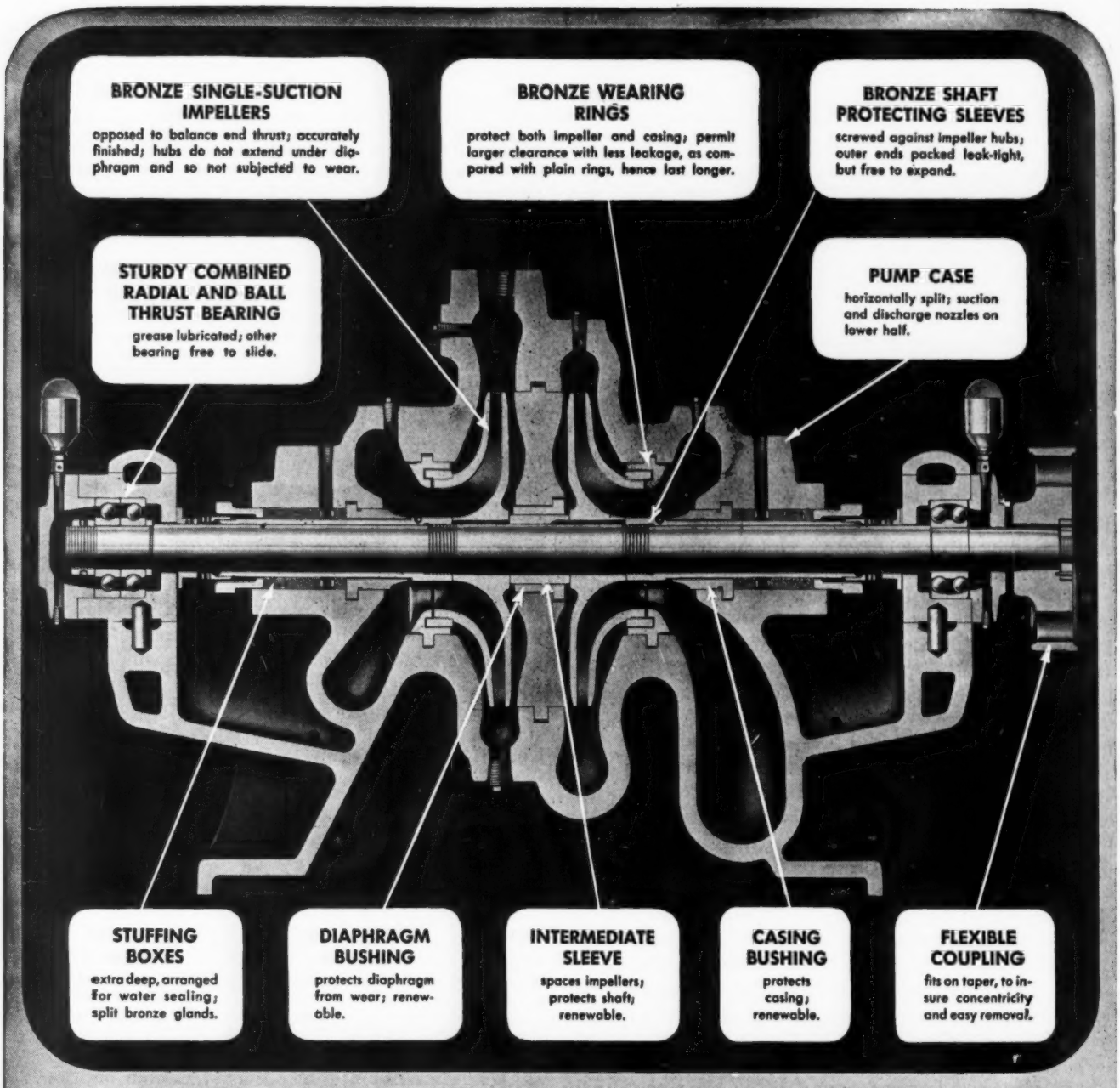
The opinion is offered that for outputs of over 20,000 kw, the steam turbine holds the undisputed field, considering efficiency, initial outlay, fuel consumption and space requirements as they apply to large units.

The foregoing is based on operation with gaseous or liquid fuels. Development work with pulverized coal, which has been in progress for some time at the Brown Boveri works, has not yet been concluded and it is believed that considerable time must elapse before such a turbine is ready for sale.

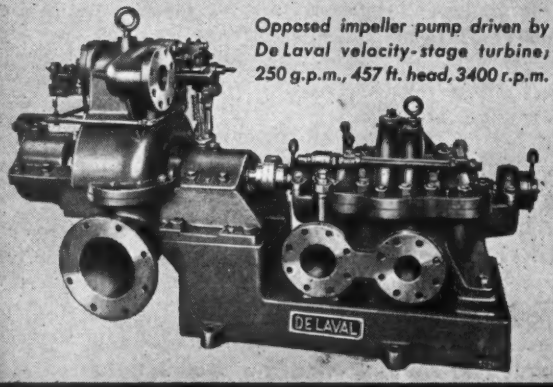
The Gas-Turbine Locomotive

The review contains information on a combustion-turbine locomotive which Brown Boveri built for the Swiss Federal Railways. This has been in regular service since May 1943 covering about 100 miles daily in mixed passenger and freight service with frequent stops and starts. Satisfactory performance is reported.

This locomotive, which is rated at 2200 hp and has a top speed of about 70 miles per hour, runs on cheap fuel oil, high-grade diesel oil being used only for starting. The low-grade oil is preheated to 212 F by the heat inherent in the exhaust gases and is injected at a pressure of about 170 psi.


BRONZE SINGLE-SUCTION IMPELLERS
opposed to balance end thrust; accurately finished; hubs do not extend under diaphragm and so not subjected to wear.
BRONZE WEARING RINGS
protect both impeller and casing; permit larger clearance with less leakage, as compared with plain rings, hence last longer.
BRONZE SHAFT PROTECTING SLEEVES
screwed against impeller hubs; outer ends packed leak-tight, but free to expand.
STURDY COMBINED RADIAL AND BALL THRUST BEARING
grease lubricated; other bearing free to slide.
PUMP CASE
horizontally split; suction and discharge nozzles on lower half.
STUFFING BOXES
extra deep, arranged for water sealing; split bronze glands.
DIAPHRAGM BUSHING
protects diaphragm from wear; renewable.
INTERMEDIATE SLEEVE
spaces impellers; protects shaft; renewable.
CASING BUSHING
protects casing; renewable.
FLEXIBLE COUPLING
fits on taper, to insure concentricity and easy removal.

DE LAVAL *OPPOSED* IMPELLER PUMP



Opposed impeller pump driven by De Laval velocity-stage turbine; 250 g.p.m., 457 ft. head, 3400 r.p.m.

In this pump the two single-suction impellers have their suction inlets facing outwardly, thus balancing the pump hydraulically and requiring only two pairs of wearing rings. High efficiency is thus combined with simple construction. Pumps built in capacities up to 1500 g.p.m. and for heads up to 800 ft. Ask for Catalog P-3226.

DE LAVAL STEAM TURBINE CO. . . TRENTON, N. J.

Measurement of Boiler Circulation by Means of Pitot Tubes

By T. Ravese
Combustion Engineering Company

Description of a modified form of pitot tube now being employed to measure the flow in boiler tubes, particularly at high pressures. A discussion of its application is included.

MODERN steam boiler design, involving numerous water circuits, complicates the problem of accurately evaluating the circulation produced, particularly under various load conditions. Hence, field measurements of circulating water quantities are most desirable, for the data thereby obtained serve both to substantiate design values and to detect and correct those circuits in which circulation may be sluggish.

Measurement of flow in a tube may be accomplished by one of several methods, among which is use of the pitot tube. The pitot tube has the following advantages when used to determine the flow in boiler circuits:

1. It does not introduce additional pressure loss in the circuits, as it obstructs very little of the tube cross-section—less than 8 per cent of the cross-sectional area of a 0.92-in. I.D. tube being thus taken up, and proportionately less in a tube of larger diameter.
2. It can be installed and removed without damage to the boiler tube.
3. It can be calibrated in an identical tube set-up prior to installation in the boiler.

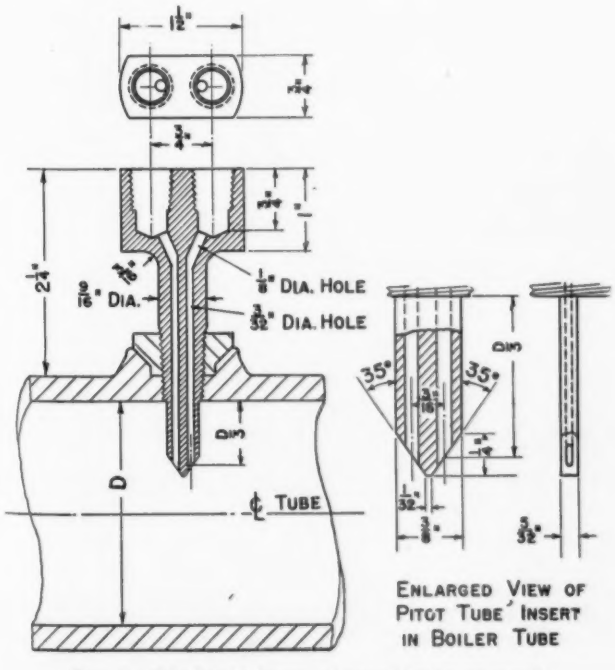


Fig. 1—Modified form of pitot tube as used

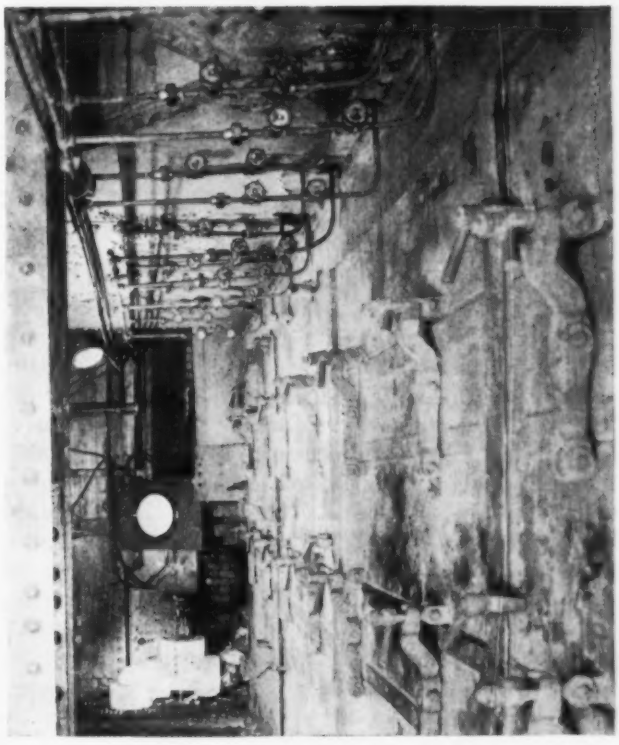


Fig. 2—Pitot tubes, double-valved and connected through manifold to recorder

The design of pitot tube and metering arrangement here described is in successful use for the measurement of flow in furnace wall tubes and downtake pipes at various boiler pressures and has been used up to 1900 psi. Inasmuch as the same basic design of pitot tube will apply to both, only the former will be described.

It is essential that the fluid density in the boiler tube be known at the pitot-tube location which preferably should be in a zone of little or no heating so as to assure fluid homogeneity. A calorimeter of suitable type is employed for checking quality.

The pitot tube here described is a modified design of the reverse type of tube and is suited to low velocity measurements. Fig. 1 represents dimensional views of the pitot tube employed, which is machined from a solid steel block, a feature that precludes possibilities of leaks. Accuracy in machining is essential and the open-end connections must be free from burrs, otherwise plugging and flow disturbance may result.

The most important part of the pitot tube is the tip end which projects into the boiler tube. An enlarged view of this section is also shown in Fig. 1. It is partly rectangular and terminates in a V with an angle of 70 deg. The length will vary with the internal diameter of the boiler tube and is one-third the latter. This projecting part is finished smooth.

Two $^3/_{32}$-in. holes are drilled through the tip and merge into $^1/_8$-in. holes just below the block end which contains the $^1/_4$-in. pipe pressure taps. It is important that the $^1/_8$-in. holes terminate as shown, as over-drilling may result in short-circuiting. After the drilling operations have been completed the holes should be thoroughly cleaned and care taken to see that no chips remain.

The pitot tube is inserted in the boiler tube to the correct depth as indicated in Fig. 1, the wall thickness having been gaged accurately at this location. Pressure taps are made up with $^1/_4$-in. extra-heavy steel nipples and $^1/_4$-in. steel globe valves employed. These valves should be suitable to the pressure encountered, 3000-lb standard having been employed for the very high pressures previously mentioned. The valves should not be of bulky design, so as to permit the insertion of pitot tubes in adjacent boiler tubes. All screwed joints are made up with "Copolite" and in some cases the assemblies are seal-welded. It is advisable to double valve each pressure tap as an added precaution against leakage.

Calibration and Meter Installation

Inasmuch as the pitot tube described is a departure from standard design, it is necessary to calibrate it for each diameter of tube in which it is used. For this purpose the pitot tube is installed in an identical boiler tube section and weighed or metered water is passed through the latter. The flow is varied to cover the range which is anticipated in the actual boiler and the pitot-tube pressure differentials are observed at each test point. It is important that the water flow be maintained uniform at each calibration point. A constant head tank is recommended for this purpose.

The pitot tube may be calibrated with cold water at low pressure and these data corrected to the actual operating conditions of the boiler. It has been established that this procedure does not involve any appreciable error.[1]

In Fig. 4 is shown a typical cold-water calibration curve[2] for a pitot tube of the design described and installed in a boiler tube 0.985 × 1.25 in. diameter, together with the correction formula. The range of calibration is from 0.5 to 4 ft per sec and shows good uniformity above one foot per second. For a given velocity this pitot-tube calibration curve gives 69 per cent more pressure differential than the standard impact-type pitot tube. This characteristic is desirable in low-velocity measurements because the meter accuracy is better generally at the higher differential pressures.

The accuracy of the measurements depends not only upon the care with which the calibration and installation work is done but also on the sensitivity and accuracy of the differential pressure-indicating or recording

[1] "Studies of Heat Transmission Through Boiler Tubing," *Trans.* A.S.M.E., August 1943.

[2] This calibration was made using "Meriam" manometers and "Vizzene" as the indicating fluid.

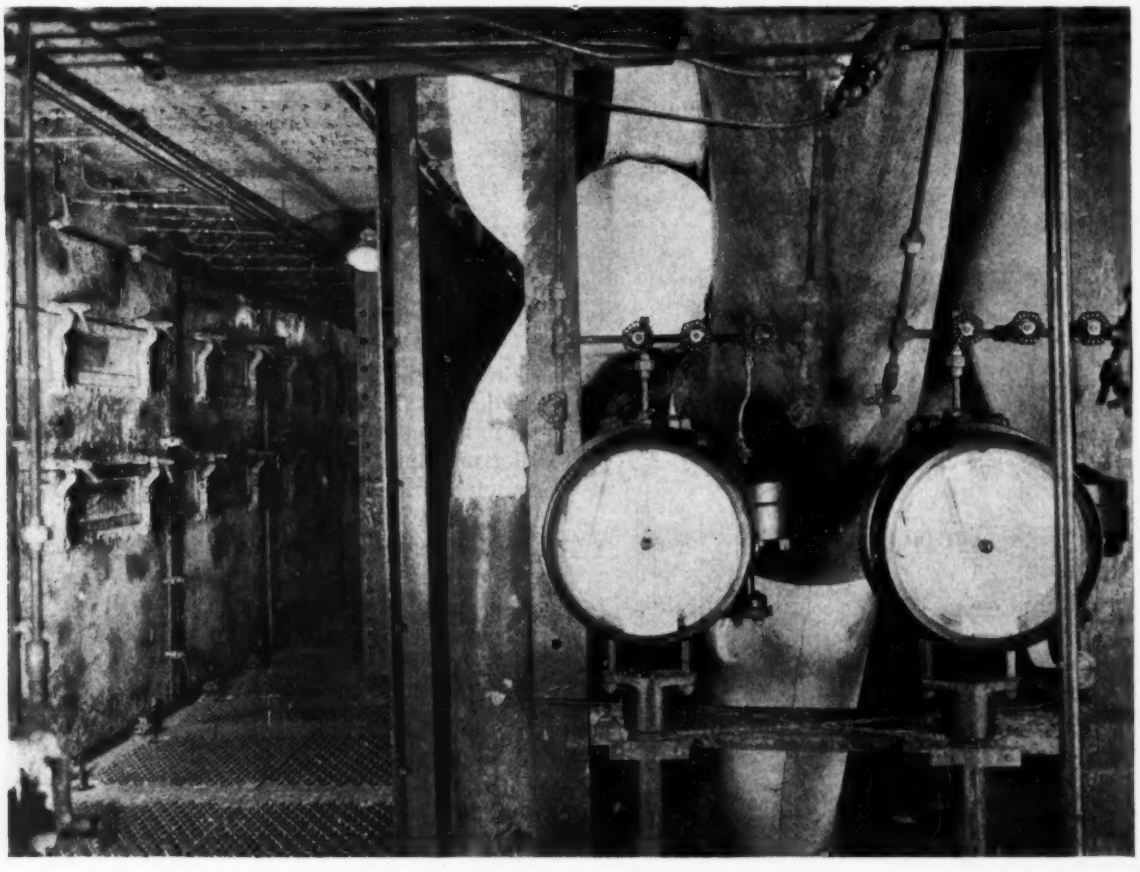


Fig. 3—Close-up of two of the four recorders

instrument. The instrument must function at boiler pressure and have a suitable range of scale so that small pressure differences can be measured accurately. There are a number of such instruments on the market.

The pitot-tube differential pressure is small and therefore the slightest leak will produce a temperature difference in the meter leads which may produce a differential pressure. Valve-stem packing glands should be carefully inspected for leaks. Meter-lead leakage is avoided by the use of seamless-steel tubing welded to the pipe fittings at the terminal ends. Furthermore, the meter leads should be properly pitched to avoid air pockets.

Pitot-tube velocity measurements have been made in boilers of both natural and controlled forced circulation. Generally, the forced-circulation unit employs a simpler and more direct water circuit which makes it possible to make velocity measurements by more than the one method. It has been found in such cases that measurements check to within about 10 per cent and checks to better than 5 per cent are common.

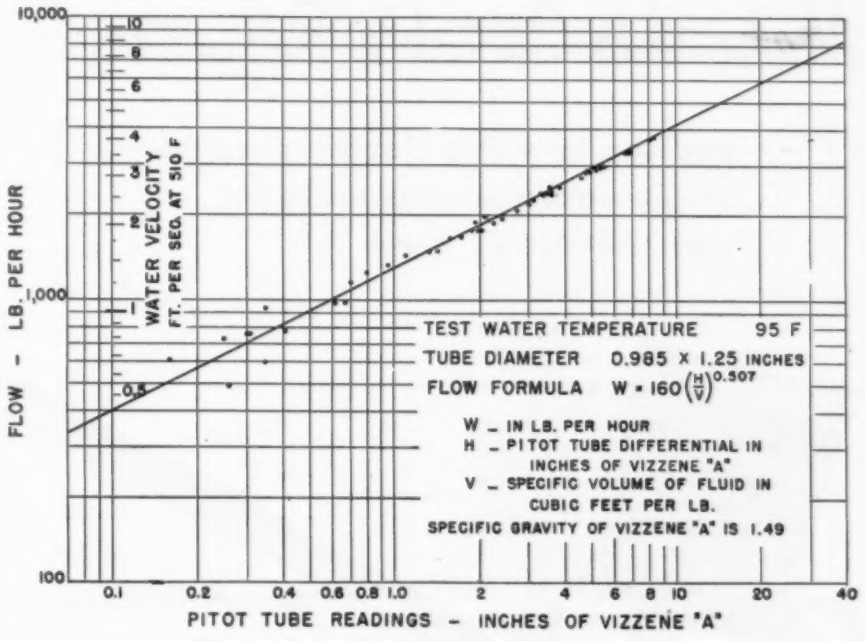
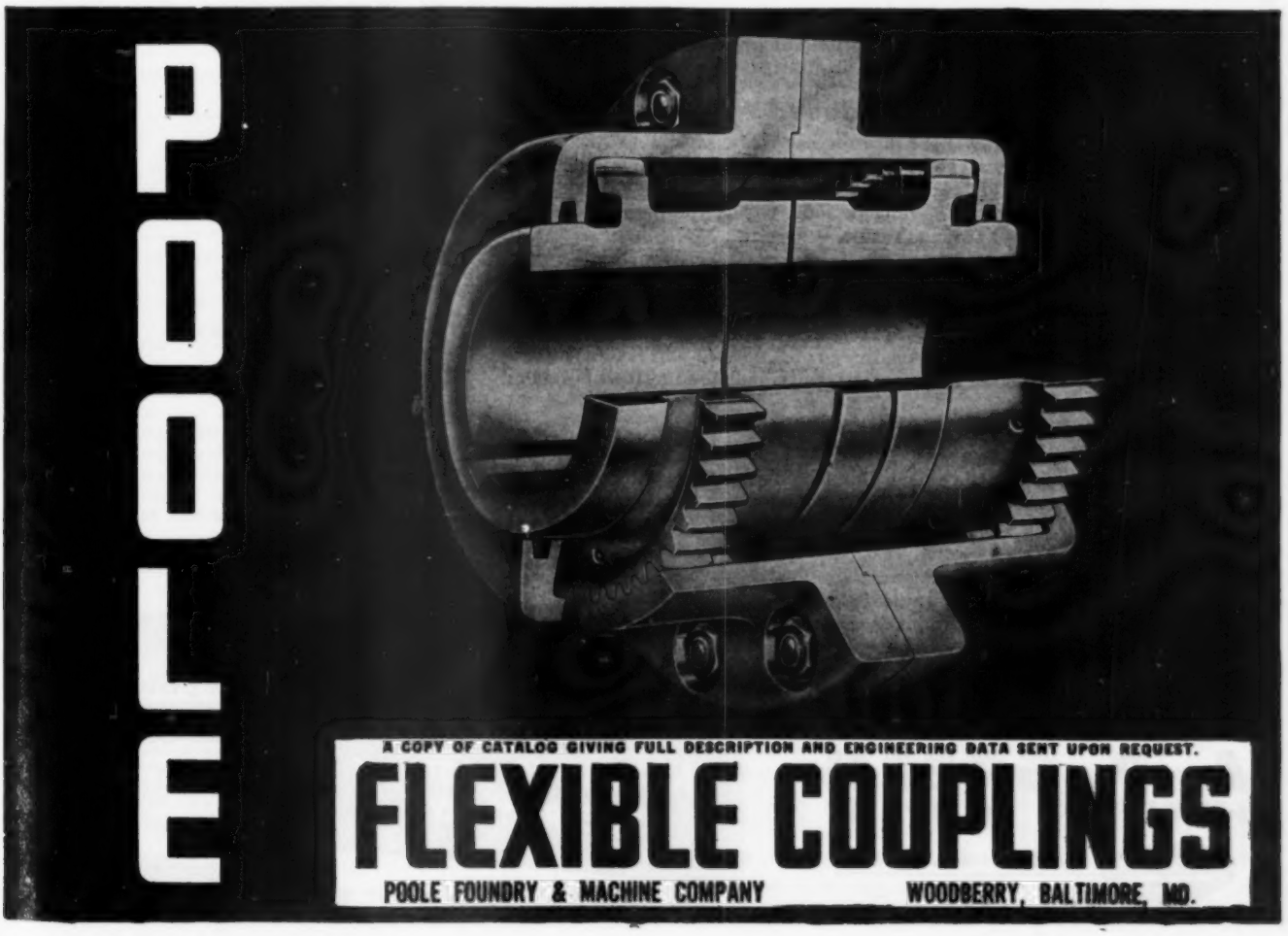


Fig. 4—Typical cold-water calibration curve

CORRECTION—Our attention has been called to the fact that the captions were interchanged for Figs. 4 and 5 of Mr. Nicolai's article on "Combustion Calculations by Graphical Methods—Refinery and Oil Gas" in the August issue, pages 46 and 47.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Because of its low heat storage capacity, KAST-O-LITE produces a higher wall surface temperature. By reducing heat losses and heat storage, radiant heat properties are developed that shorten heating and cooling periods. Closer temperature control is possible. Fuel savings result.

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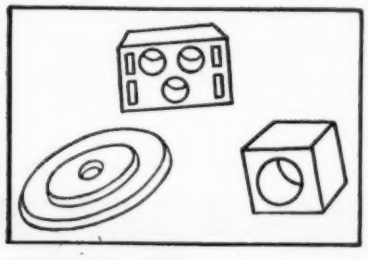

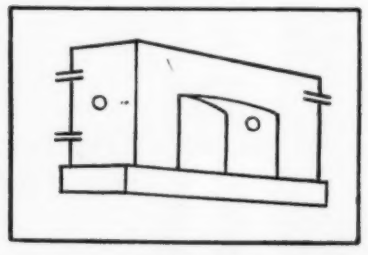

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Some Notes on Boiler Baffling

The following observations on baffling are the outcome of a reply to some questions from a reader which was later expanded with the thought that it might be informative to others. The subject has been dealt with broadly without attempting to mention proprietary types, or discussing boilers that require special arrangements of baffling.—Editor

THE purpose of baffles is to direct the products of combustion so as to secure the most effective heat transfer to the boiler tubes and to provide the desired path for the gases over the superheater and heat-recovery surfaces; also to direct part of the gas over only a portion of the superheater, when desired, if damper control of superheat is employed. It is most important that the baffling be arranged so as to keep within the permissible draft loss for the particular unit.

Draft loss through a boiler varies within wide limits and is influenced by a number of factors such as size and type of unit, arrangement of heating surface and baffles, character of fuel and method of firing, and rate of output. In small units it is frequently under one inch, wg whereas in some large units it may be as high as seven or eight inches for boiler and superheater.

As far as possible, the arrangement of baffles should be such as to afford uniform gas velocity, this being accomplished by providing tapered gas passages to compensate for reduced volume as the gases become cooler on their way through the unit. This will result in maximum heat recovery without unnecessary increase in draft loss. Sharp turns are to be avoided as they tend to increase draft loss, set up eddy currents and afford areas for accumulation of ash and soot. It is also important to provide for the convenient inspection, repair and blowing of baffles.

With oil, gas or pulverized-coal firing, location of the burners may have bearing on baffling of the first gas passages.

There are two broad classes of baffling, namely, cross and longitudinal. As the terms imply, cross baffling, which also includes baffles inclined to the tubes, directs the hot gases across the tubes and longitudinal baffling directs them along the tubes. Many combinations of the two types exist. Monolithic construction, special firebrick tiles and metal plate baffles are in use.

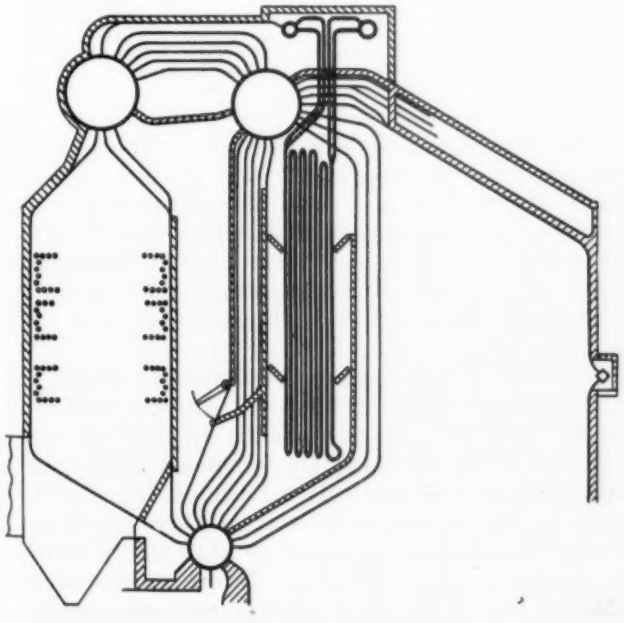

Fig. 1—Three-drum boiler with longitudinal baffling and damper control

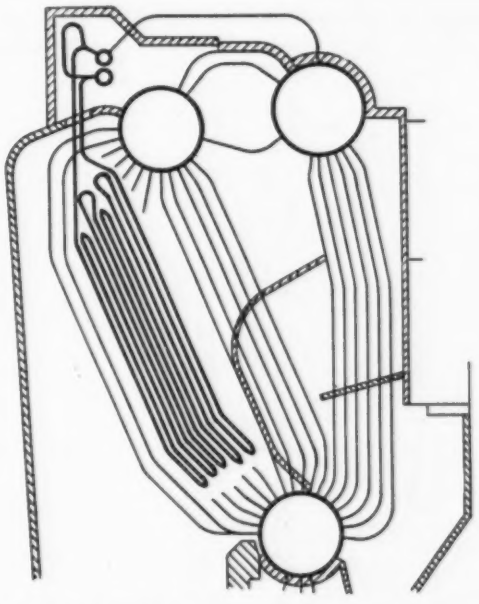

Fig. 2—Three-drum boiler with cross baffling

For a given gas velocity, the heat transfer is considerably greater with cross baffling than with longitudinal baffling, but the extent to which it can be applied depends upon the arrangement of boiler surfaces, the distance between the upper and lower drums in the case of bent-tube designs and the desired location of inlet and outlet of the tube bank. Thus, while cross baffling is common with two-drum stationary boilers of small and moderate capacity, except in the superheater section, as it also is with three- and four-drum boilers of medium size, the drum centers of large multi-drum units are usually so great that for efficient use of heating surface employment of all cross baffling would entail too many passes with resulting excessive draft loss. In some such cases, longitudinal baffling is used throughout whereas in others a combination of the two types works out best.

It often becomes necessary at some point to employ longitudinal baffles, for if the gas velocity were to be reduced, the heat transfer, which depends on mass flow, would actually be less with cross baffling. Moreover,

in many large units finger baffles are placed in the later passes to provide both cross and longitudinal flow and thereby increase the heat transfer. Occasionally finger baffles are to be found in front of part of the superheater for the same reason. The finger baffle is placed between rows of tubes across the tube bank, thus permitting part of the gas to pass at right angle to the tubes and the remainder parallel with the tubes.

To illustrate the foregoing, three sketches, Figs. 3, 4 and 5, are presented showing three types of baffles as applied to a two-drum bent-tube boiler. Fig. 3 shows cross baffles which are commonly used for units having a distance between drum centerlines of 20 ft or less. Fig. 4 shows longitudinal baffles with the same boiler. It is apparent that as the drum center distance of these two boilers is increased the gas velocity remains unchanged in Fig. 4, whereas it is reduced with the cross-baffled arrangement of Fig. 3. Obviously, there is a point where the heat recovery of the two boilers will be the same and as the height is increased beyond that point longitudinal baffles will be more efficient.

It will be noted that the gas outlet of Fig. 4 is at the bottom of the tube bank. Due to the arrangement of equipment to follow the boiler it is more often more convenient to locate the outlet at the top. To meet that condition, finger baffles as shown in Fig. 5 are often substituted. The gas velocities in general are lower than with longitudinal baffles since only one vertical pass is required within the main tube bank instead of two. The added turbulence in the gases induced by the finger baffles so increases the efficiency of heat transfer as to equal the performance of Fig. 4. The draft loss through the two boilers is essentially the same.

With boilers of the bent-tube multi-drum type, where high steam temperatures are involved, the front baffle ahead of the superheater is usually protected from the radiant heat of the furnace by two or more rows of closely spaced boiler tubes, or the baffle may consist of finned tubes backed with tile.

Straight-tube boilers of either the box- or sectional-header types may employ either longitudinal or cross baffling, depending upon the furnace and tube arrangement, the location of the superheater, if used, and that of the exit gases. In recent years, however, preference has been toward the cross baffling, especially where a superheater forms part of the unit. Although the longitudinal baffling, as in Fig. 6, is somewhat simpler, consisting of tile resting on the tubes, the cross baffling in this case insures more tube surface in contact with hot gases, produces turbulence, and is more efficient. Sometimes in order to permit greater furnace volume a combination of cross and longitudinal baffling is employed, the latter extending part way from the rear above the lower two or three rows of tubes.

Rearrangement of Baffles

At this point it may be desirable to mention the popular movement toward converting horizontally baffled box-header boilers to cross baffling. It is true that this change will increase the efficiency of heat absorption. However, there are other factors which an operator should consider before making this change. Some of these are as follows:

The vertical spacing between tubes of such a boiler designed for horizontal baffles is usually considerably less than when designed for cross baffles. This was done to increase the gas velocity for flow parallel along the tubes. If, however, any tubes have warped the clearance between tubes may be materially reduced. While this would not affect performance when horizontally baffled, the gas velocity and resultant draft loss might be excessive when gases are directed back and forth across the tubes.

The location of soot blowers for effective cleaning of heating surfaces requires different treatment with cross baffles. Also, with some designs the circulation of water and steam within the boiler tubes is more positive when horizontally baffled, particularly when operating at high rating. There have been some cases where overheating of tubes occurred on converted boilers thereby limiting the maximum rating allowable. Before rearranging the baffles on any boiler, it is strongly recommended that the manufacturer's advice be obtained in order to obviate any of the foregoing difficulties.

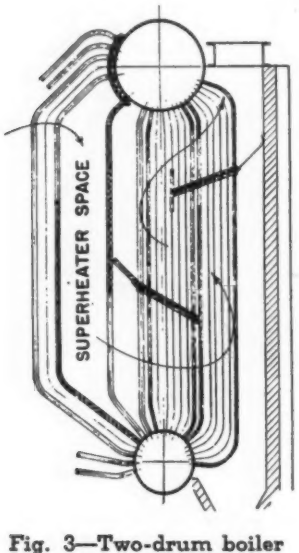

Fig. 3—Two-drum boiler with cross baffles

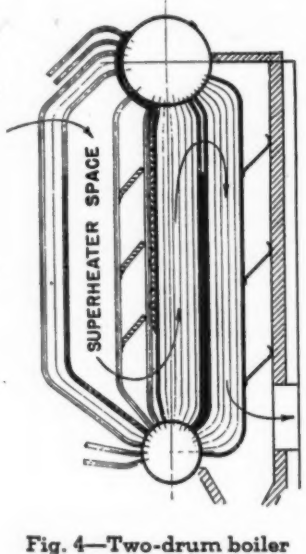

Fig. 4—Two-drum boiler with longitudinal baffles

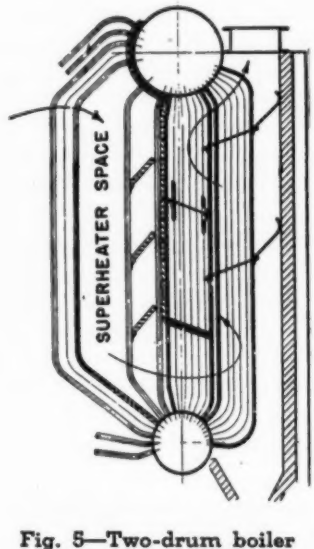

Fig. 5—Two-drum boiler with finger baffles

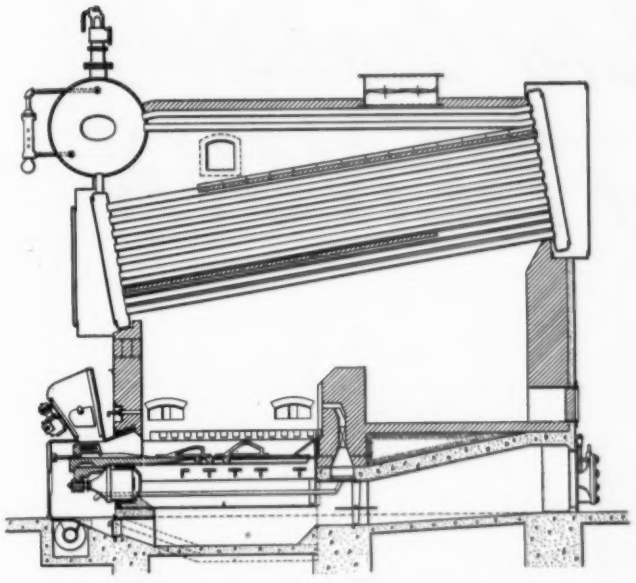

Fig. 6—Straight-tube boiler horizontally baffled

Baffling Air Heaters

Another point of interest is the development of baffles for tubular air heaters. Formerly it was standard practice to design heaters with a single path of gas through the tubes and a single pass of air outside and along the tubes. In recent years there has been a demand for higher air temperatures which require larger and more efficient heaters. In general, the gas is still directed through the tubes but the air instead of flowing parallel with the tubes is directed back and forth across the tubes two or more times. This is done to maintain effective velocities and take advantage of the more efficient heat transfer of cross flow. It can be appreciated that when very high air passages are used so as to maintain a low velocity corresponding to a given pressure drop it would be possible for the air to take a diagonal path across the tubes from one baffle opening to the next thereby rendering part of the heating surface ineffective. A continuous division plate or baffle is sometimes used so as to divide the air into two or more parallel streams thus reducing the height of any single pass and the tendency to bypass heating surface. Since the actual velocity of the air has not been affected the pressure drop will also remain the same. A typical illustration of this is shown in Fig. 8.

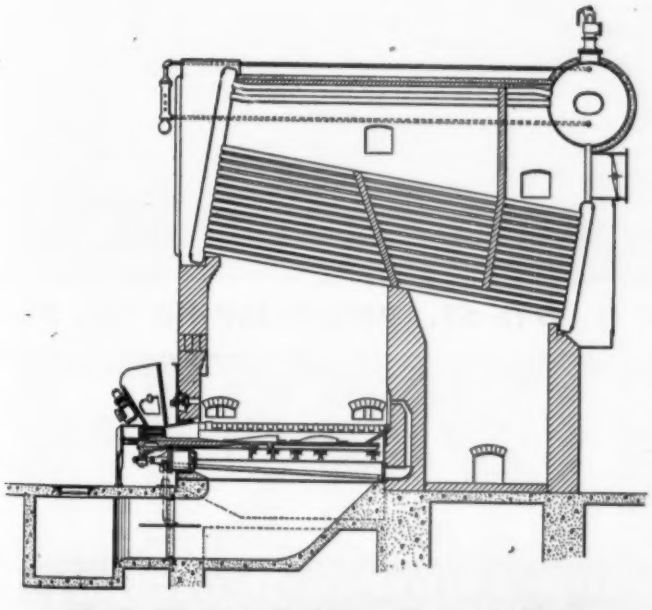

Fig. 7—Straight-tube boiler with cross baffling

Baffle Construction

As previously noted, baffles may consist of firebrick tiles, castable self-hardening blocks or monolithic construction.

Flat tiles as employed for longitudinal baffling of straight-tube boilers merely rest on the tubes and are held in position by their own weight. When used on bent-tube boilers, they are generally held in place by clips or lugs. Formed tiles are sometimes employed instead of flat tiles. Where differential pressure across the baffle is great it is well to make them ship-lapped both ways to avoid cutting of the tubes at the joint.

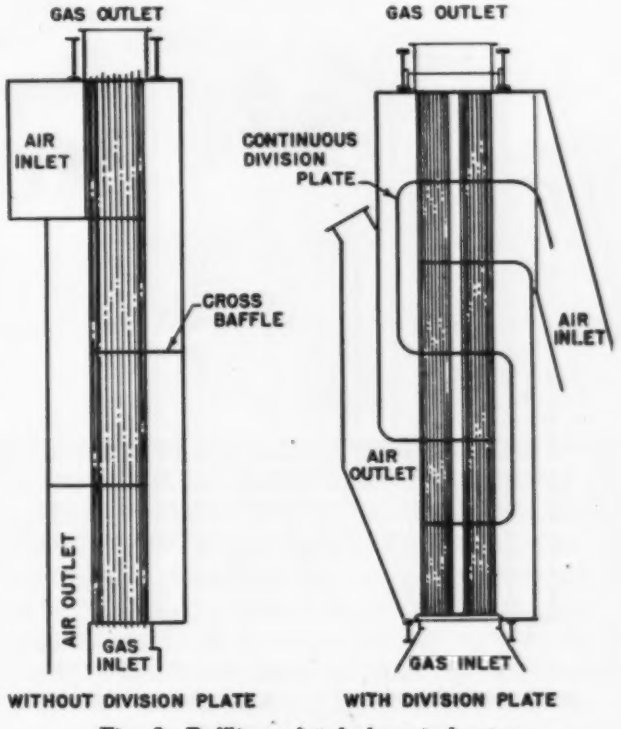

Fig. 8—Baffling of tubular air heater

Cross baffling, however, requires the use of blocks fitting around the tube or monolithic construction. Such tube blocks are usually made from plastic material, having the required coefficient of expansion and built up in the field to fit the tube and space, with suitable expansion joints and, where necessary, steel reinforcing; or they may consist of specially formed interlocking blocks to assure alignment and lightness. A special form of tube block is used where it joins the bridge wall.

With either monolithic construction or cast blocks and cross baffling tubes in straight-tube boilers may be removed with little or no damage to the baffle, or if damage occurs due to a warped tube it can usually be readily repaired with plastic refractory. With bent-tube boilers employing cross baffling and tube blocks, special tiles are set in the wide spacings and arranged so that they can be removed to provide space for removal of a tube. However, it is seldom necessary to remove bent tubes.

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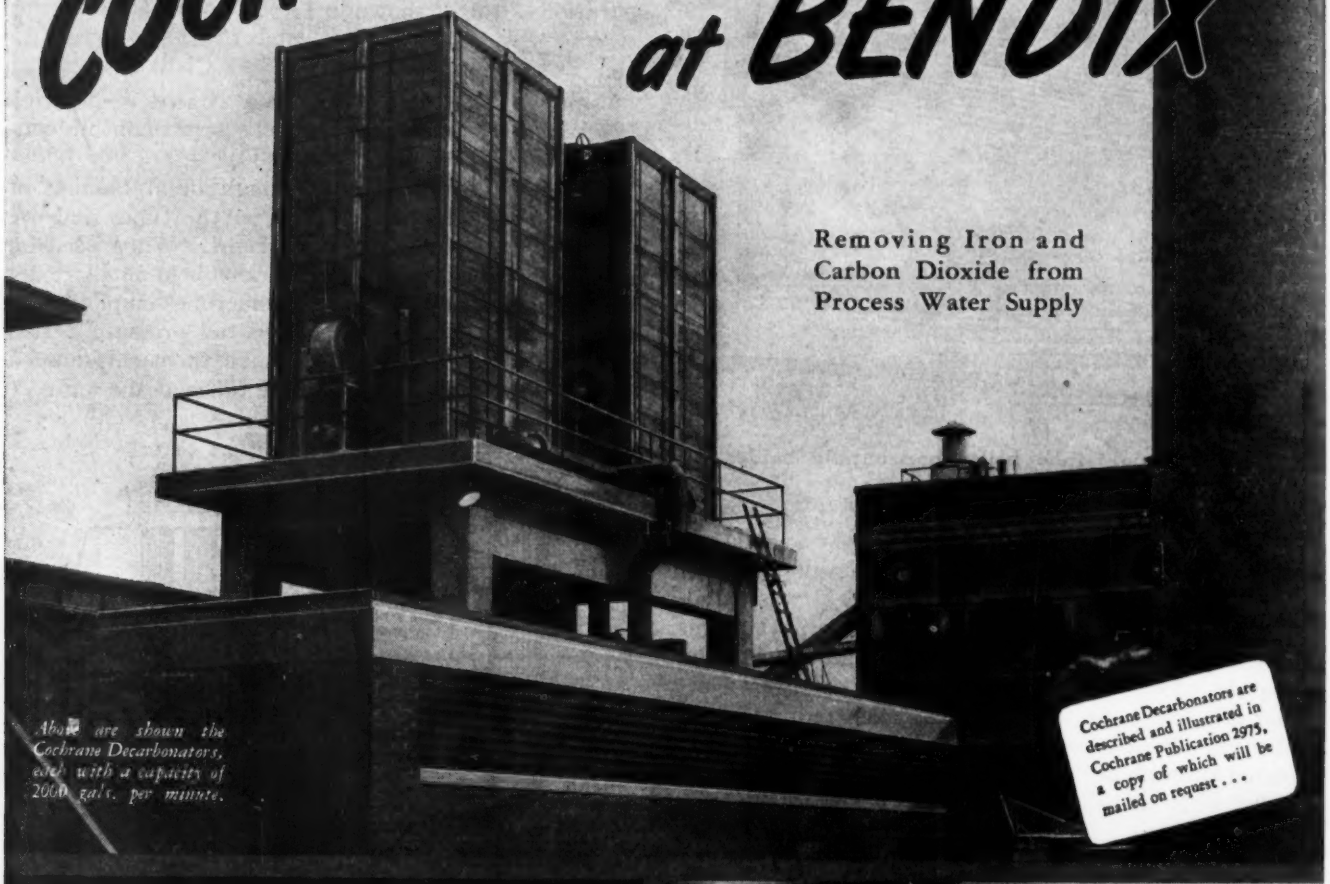
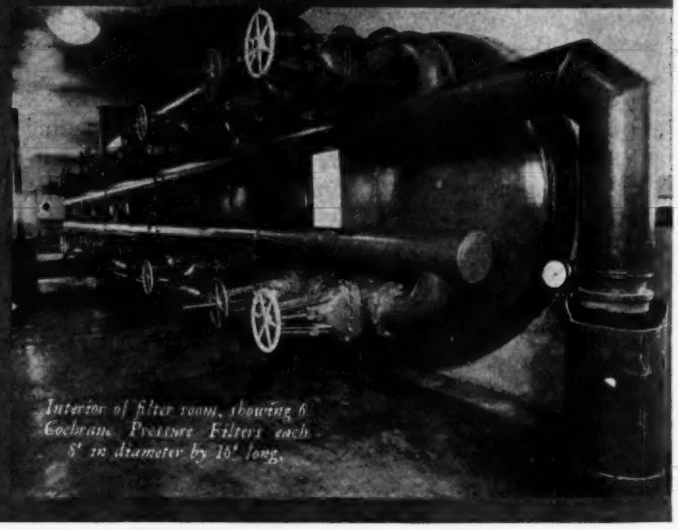


Removing Iron and Carbon Dioxide from Process Water Supply

Above are shown the Cochrane Decarbonators, each with a capacity of 2000 gals. per minute.

Cochrane Decarbonators are described and illustrated in Cochrane Publication 2975, a copy of which will be mailed on request . . .

THE war load on Bendix Aviation Corporation was naturally a very heavy one and involved rapid and extensive expansion of plant facilities. At the South Bend plant, water supply became a vital problem, which was solved by sinking two wells on the premises and installing the necessary pumps and pipelines. To insure the finest water possible, Cochrane water conditioning equipment was installed consisting of two rectangular Cochrane Decarbonators, each designed for a capacity of 2000 gallons per minute. By aeration, the iron is oxidized and precipitated and the carbon dioxide and some hydrogen sulphide removed. After aeration, the water is filtered through six Cochrane Pressure Filters, each 8' in diameter by 16' long, charged with sand and gravel. The installation is the largest of its type in the Midwest.



Interior of filter room, showing 6 Cochrane Pressure Filters each 8' in diameter by 16' long.

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Hydrogenation and Liquefaction of Coal and Lignite

A review of what has been accomplished abroad; typical yields from various U. S. coals, as established by preliminary research; and the program for extensive research and development by the U. S. Bureau of Mines as provided by appropriation under the recent Synthetic Liquid Fuels Act.

IN A paper presented informally last February before the A.I.M.E. at New York, but only recently released in complete form by the Bureau of Mines and the Institute, A. C. Fieldner, H. H. Storch and L. L. Hirst reported on the hydrogenation research that has been under way with a small unit at the Pittsburgh Experiment Station of the Bureau.

This experimental work on liquefaction of coal, which is described in detail in the paper, was undertaken in 1936 when it became evident that a prudent policy from the national viewpoint should include preparation for the time when gradual exhaustion of petroleum resources would require the production of oil from coal to meet the growing demand.

At the time, certain foreign nations which had no home petroleum resources, especially Germany, England and Japan, were conducting active research; and at least two of them were producing liquid fuel from coal on a commercial scale. Germany was reported then to have had an annual producing capacity of 800,000 metric tons of gasoline, which has probably since been greatly stepped up; and England had put into operation the Billingham plant of Imperial Chemical Industries for the hydrogenation of bituminous coal and tar by the Bergius-I.G. process. The annual capacity of this plant was about 3500 bbl per day.

With these developments taking place abroad, it was important to undertake a long-range program of fundamental research to establish a sound groundwork

TABLE 1—LIQUEFACTION YIELDS OF COALS OF DIFFERENT RANKS AND TYPES AND OF THEIR PETROGRAPHIC CONSTITUENTS

Rank, Type or Petrographic Constituent	Liquefaction Yield, Per Cent by Weight of Dry, Ash-Free Coal, Usual Range
Anthracitic rank	Less than 70
Bituminous low-volatile rank	70 to 90
Bituminous medium-volatile rank	75 to 95
Bituminous high-volatile and sub-bituminous ranks	85 to 96
Lignitic rank	90 to 97
Bright coal type below medium-volatile rank	85 to 97
Splint and semi-splint coal types	65 to 85
Cannel and boghead coal types	70 to 98
Translucent anthraxylon, translucent attritus, spore-exines and algae remains	95 to 98
Resins	98 to 100
Opaque attritus	40 to 80
Fusain	10 to 50

for the evaluation of this foreign work on synthetic liquid fuels and to obtain data on oil yield and operating difficulties with various American coals and lignite.

The industrial liquefaction of coal by the Bergius-I.G. hydrogenation process, as practiced at Billingham, is carried out in two stages—the primary, or liquid, phase and the vapor phase. Liquid-phase hydrogenation is accomplished by mixing a small amount (usually less than 0.1 per cent of the weight of the coal) of a suitable catalyst, preferably a tin compound, with approximately equal parts of pulverized coal and heavy oil previously obtained in the process. This paste is then pumped through a preheater in a high-pressure steel vessel through which hydrogen gas is pumped at a pressure of about 3000 psi. The preheater raises the temperature of the reacting mass to about 860 F. The oil product from the reaction vessel is separated from the solid residue of ash-forming material and unliquefiable carbonaceous matter, and is distilled into light, middle and heavy oil fractions. The light oil is refined into gasoline, the middle oil is hydrogenated further and the heavy oil goes back into the process.

Four to five tons of high-volatile bituminous coal, seven tons of sub-bituminous coal, or about nine tons of lignite are required to produce one short ton of gasoline. This corresponds with 0.6 to 0.8 short tons of high-volatile bituminous coal, one ton of sub-bituminous coal; or 1/3 ton of lignite per barrel of gasoline. The octane rating of the gasoline at that time was 70 to 75 which was raised to 80 or 85 by the addition of tetraethyl lead.

Since the primary objective of the Bureau of Mines research was to assay the hydrogenating properties of various American coals and lignites, most of the experiments were confined to the primary or liquid-phase stage. In other words, the liquefaction of coal was conducted mostly to produce a crude oil.

It has been generally recognized by European investigators that the degree of liquefaction of a coal in the hydrogenation process varies inversely with the rank of the coal; that is, with the extent of metamorphism from lignite to anthracite. Peat, lignite, sub-bituminous and high-volatile bituminous coal are almost completely liquefied. Coals containing more than 89 per cent carbon on the dry, ash-free bases, such as medium-volatile, low-volatile bituminous and anthracite are unsuitable under conditions appropriate for commercial hydrogenation.

The viscosity of the pitches increased with the rank of the coal. Those from high-rank anthraxylous were brittle, friable solids at room temperature, whereas those from low-rank coals were semi-solid. Since this pitchlike product is used as a vehicle, or "pasting oil," in commercial hydrogenation, its viscosity is of practical importance.

The total yield of gases, excluding hydrogen, decreased from a maximum of about 24 per cent by weight for peat to a minimum of about 1 per cent for anthracite, the decrease in gas yield having a general relationship to increase in rank of coal. This decrease is largely because of the decrease in yield of carbon dioxide as the oxygen content of the coal becomes less.

The yield of phenols in per cent by volume of the distillate up to 428 F increased with decreasing carbon content, from an average of about 2 per cent for low-volatile and medium-volatile bituminous coals to about 6 per cent for lignite. A summary of the ease of liquefaction of coals of different ranks and their principal petrographic constituents is given in Table 1.

TABLE 2—AVERAGE YIELD UNDER OPTIMUM CONDITIONS FROM THE LIQUID-PHASE HYDROGENATION OF PITTSBURGH-BED COAL FROM U. S. EXPERIMENTAL MINE

Product	Percentage of Dry, Ash-Free Coal Plus Hydrogen Absorbed
Oil product	64–68
Gaseous hydrocarbons, methane to butane inclusive, plus carbon oxide gases	20–25
Oxygen, nitrogen and sulphur hydrogenated to water, ammonia and hydrogen sulphide	3–6
Unreacted fusain and opaque attritus	6–8
Composition of Oil Product	**Percentage by Volume**
Oil boiling in the gasoline range below 401 F. (205 C.)	20
Oil boiling from 401 to 626 F. (205 to 330 C.)	70
Tar acids	15–18
Tar bases	3–5
Neutral oil	77–82
Composition of Neutral Oil	**Percentage by Volume**
Olefins	3–5
Aromatics	67–70
Saturated hydrocarbons (paraffins plus naphthenes)	22–27

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From this investigation it is evident that only the common banded bright coals ranging in rank from lignite to high-volatile bituminous are to be considered as potentially suitable for commercial hydrogenation.

The average yield under optimum conditions from the liquid-phase hydrogenation with Pittsburgh-bed coal from the U. S. experimental mine is shown in Table 2, and yields from other coals are given in Table 3.

Conclusions, based on the investigation made thus far are that the major part of American coal reserves are suitable for liquefaction. This part includes the common bright coals of high-volatile bituminous, sub-bituminous and lignitic rank. Coals low in ash and nearly free from fusain and opaque attritus were almost completely liquefied. The most favorable operating conditions for the maximum yield of oil vary with different coals; but the physical characteristics and chemical composition of the resulting oil are influenced principally by the operating conditions.

Plans for Research and Development by the U. S. Bureau of Mines

A late announcement by Secretary Ickes, under date of September 17, states that the Bureau of Mines is planning to send engineering survey parties into the field to examine potential locations for synthetic liquid-fuel laboratories and demonstration plants. Authorized by the Synthetic Liquid Fuels Act, these laboratories and plants will conduct a five-year program of research and development to provide the "know how" for private commercial production of oil and gasoline from our large reserves of coal, lignite, oil shales and agricultural and forestry products. To date, more than 150 site proposals have been submitted to the Bureau of Mines and thorough consideration is being given to the qualifications of each.

Potential oil yields have already been determined for coals from fourteen different beds in the United States and Alaska and samples from other deposits are now being assayed to obtain information for the selection of the best plant sites. Operating by different processes, two demonstration plants are planned for both coal and agricultural and forestry products. A third demonstration plant is contemplated for oil shale, and experimental laboratories and small pilot plants will be set up for each of the methods.

One oil shale development and research laboratory will be established at the University of Wyoming as an adjunct to the Bureau's present petroleum experiment station at that university. The laboratory is estimated to cost $480,000 and construction will start shortly. A staff of 70 additional employees will be required to operate the laboratory, thus bringing to 85 the total staff of the Bureau at this station.

Explaining the need for new sources of liquid fuels, Secretary Ickes stated that since 1939 petroleum consumption has exceeded discoveries of new reserves in the United States and that we are using oil at a rate almost four times the rate of discovery in 1942 and 1943. The failure to increase reserves has not been due to lack of exploratory effort nor to lack of new fields but to the small size of the fields that were found. Although exploratory drilling was 50 per cent greater in 1943 than in 1937, the volume of reserves per field dropped to one-tenth of what it was in 1936.

TABLE 3—LIQUEFACTION YIELDS FOR OPTIMUM CONDITIONS OF HYDROGENATION

Origin of Coal, Mine or Town and State	Percentage of Dry, Ash-Free Coal: Hydrogen Absorbed	Oil Yield	Total Aromatic Neutral Oil Yield	Tar Acids Yield*	Tar Bases Yield	Oil Yield, Gal. per Ton Coal as Mined
1	11	12	13	14	15	16
Sayreton, Ala.	8	62	33	8	2.5	136
I.C.C. No. 21, W. Va.	11	69	35	5	2.0	156
Empire, Ala.	12	73	31	8	1.7	176
U. S. Experimental, Penna.	9	72	41	11	2.8	169
Columbia, Utah	7	74	30	11	2.6	170
Orient No. 2, Ill.	8	71	37	15	1.7	155
Saxton No. 1, Ind.	9	70	32	12	2.3	141
Strain-Upper Diamond, Wash.	8	70	28	15	3.7	155
Colstrip, Mont.	8	63	26	14	2.1	108
Puritan, Colo.	10	63	28	13	2.8	115
Monarch No. 45, Wyo.	8	66	25	16	3.1	123
Beulah, N. D.	7	54	24	12	1.6	79
Velva, N. D.	7	55	22	15	1.6	79

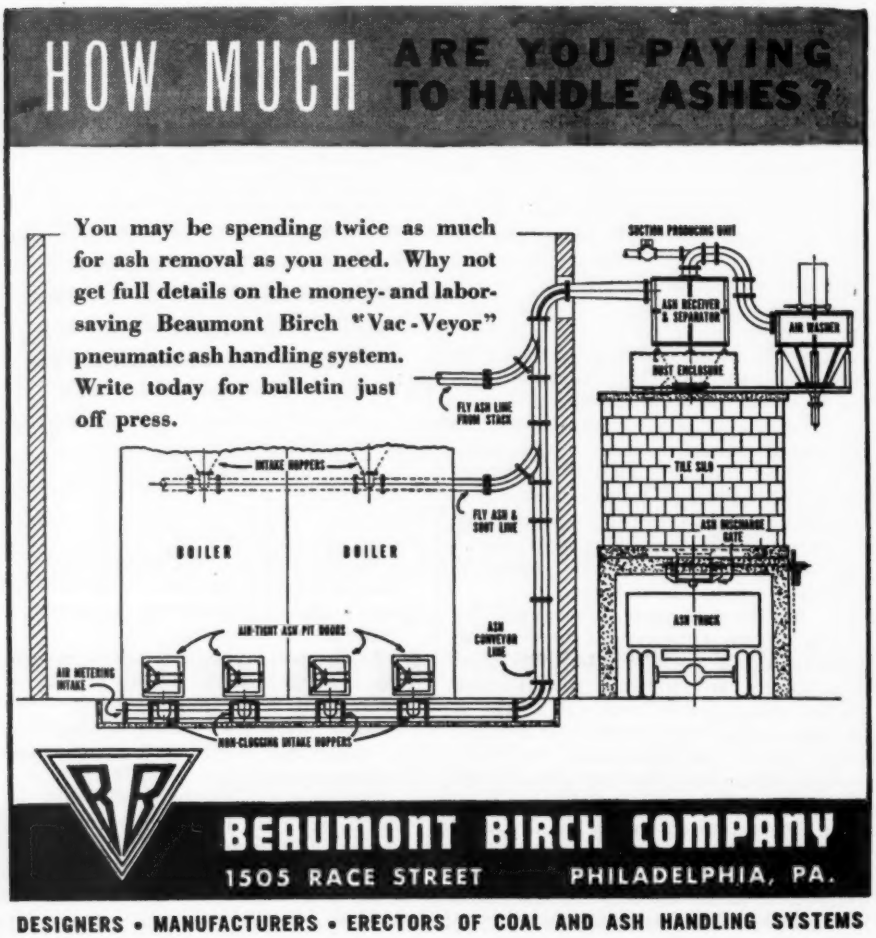
* Distilling up to 330 C.

Present Oil Reserves Estimated as Good for Fifteen Years

According to Secretary Ickes, known reserves of petroleum are estimated at slightly more than 20 billion barrels. This would be enough for approximately fifteen years at the present rate of consumption if the oil could be withdrawn that rapidly; but it cannot, as the wells produce at a high rate during only the first few years of their life. If an effort is made to accelerate withdrawals greatly, the gas pressure forcing the oil to the surface falls and oil is lost irretrievably, as has been shown by experience.

In contrast to the apparently limited natural petroleum resources, the United States has more than three trillion tons of coal reserves, and the reserves of oil shales are estimated to contain a potential supply of 92 billion barrels of crude oil—sufficient to maintain the present annual rate of oil consumption for more than sixty years.

From 1926 to 1929 the Bureau of Mines studied the extraction of oil from shales but had to discontinue the project because of lack of funds. However, the 78th Congress appropriated 5 million dollars to launch the present program which under the contemplated plans should assure an adequate supply for the future when withdrawals from present oil sources must necessarily be curtailed.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DESIGNERS • MANUFACTURERS • ERECTORS OF COAL AND ASH HANDLING SYSTEMS

Uncommon Elements in Coal

"Many of the rare and uncommon elements found in coal probably were derived from the original coal-forming plant material, whereas others occurring as minerals are considered to be extraneous substances deposited in coal beds from external sources. Although a large number of such elements occur in various coals, the percentages have apparently been considered too low to warrant industrial recovery. However, investigations of flue dusts from certain gas works in England have indicated that they are potential sources of germanium and gallium."

Thus is summarized the results of a survey by F. H. Gibson and W. A. Selvig in a report[1] just issued by the U. S. Bureau of Mines.

Analyses of a large number of samples of ash from various coals of the United States showed the common constituents to be compounds of silica, alumina, lime and iron, with smaller quantities of magnesia, titanium and alkali compounds; although some ashes contained appreciable quantities of sulphate and phosphorus compounds. The silica appears in the form of silicates and sand; the aluminum in combination with silica; the iron in various forms such as pyrite and marcasite, ferrous oxide, ferrous carbonate, ferrous sulphate, ferric oxide, ferric sulphate, organic iron and iron silicates; the calcium as carbonates and silicates; sodium and potassium as silicates, carbonates and chlorides; manganese as carbonates and silicates; inorganic sulphur in combination with iron or as calcium sulphate; and phosphorus as phosphates. These are in addition to carbon, oxygen, hydrogen and nitrogen derived in the coal from plant life. Small quantities of boron, barium copper and zinc have also been found in the ash from lignite char.

Among the rarer elements detected by spectrum analysis of flue dust are lithium, rubidium, caesium, silver, gold, strontium, selenium, vanadium, gallium, indium, thallium, titanium, arsenic, iodine antimony, bismuth, mercury chromium, molybdenum and nickel. Copper, lead, manganese and zinc were also found.

Gold content reported in the ash from certain western coals ranged in value from 60 cents to over $2 per ton of ash.

Traces of radium have also been reported by several investigators with southern and western coals as well as Russian coals and anthracites from the Donetz Basin.

The present review was based on a study of the reports of numerous investigations both here and abroad.

[1] Technical Paper No. 699.

ECPD to Review Technical Institute Programs

For ten years the accrediting of degree-granting engineering colleges has been a major activity of the Committee on Engineering Schools, one of the standing committees of Engineers' Council for Professional Development. The list of accredited curricula has been formally adopted by the national engineering societies as a basis for judging educational qualifications of prospective members and is in use by the examining boards in the forty-six states which now have professional engineer registration.

A second field of technical education, whose importance has been emphasized by the serious shortages of qualified men developed by the war effort, is at the technical institute level. After several years of study by a committee under the chairmanship of Dean H. P. Hammond of The Pennsylvania State College, a plan to inspect the work of technical institutes has been presented to the ECPD and approved by the constituent societies. It is expected that the accrediting of educational programs of the technical institute type will be carried out in a manner similar to that used for the engineering colleges. A new general accrediting committee is in the process of formation. This group, which will include representatives of industry as well as of various types of institutions offering technical institute courses, will function for the present as a subcommittee of the standing Committee on Engineering Schools.

The subcommittee report defined technical institute courses as those preparing technical aides or assistants to professional engineers and included in the scope of the proposed accrediting movement junior technical colleges, extension courses, evening schools, correspondence schools, industrial institutes and proprietary schools as well as the traditional technical institutes. It is expected that the accrediting program, which will meet a serious need and provide recognition of important educational work which has long deserved such recognition, will be inaugurated this fall. An accredited list in this field will be of tremendous value both to high school students planning post-graduation study and to industrial employers seeking qualified candidates.

Basil Manly Elected Chairman of F.P.C.

With the Senate's confirmation of the reappointment of Leland Olds as a member of the Federal Power Commission, that body held its first meeting with full membership on September 21 and elected Basil Manly as its Chairman for the period ending June 22, 1948, the date of expiration of Mr. Manly's present appointment.

Mr. Manly has served with the Commission since 1933 and has held several special assignments during the intervening period, including those of Commissioner in charge of the National Power Survey and the Electric Rate Survey, 1933–36; Vice-Chairman of the National Defense Power Committee which devised plans for the wartime mobilization of electric power supply; and Chairman of the Committee on Generation and Distribution of the National Association of Railroad and Utilities Commissioners in 1939. During World War I he was Joint Chairman with former President Taft of the National War Labor Board.

Let ONE man take care of your COAL STORAGE PROBLEMS

If you have a man power shortage, let *one* man be responsible for storing and reclaiming coal — safely — rapidly—economically—with a Sauerman Scraper System.

Sauerman Scraper System handles 165,000-ton storage pile, a 300-day supply for this Michigan generating station.

Consider these advantages:

1. Maximum tonnage stored on all available space.
2. Operation is smooth and rapid.
3. Costs only a few cents per ton to handle.
4. Eliminates excessive dust and dirt.
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7. Low original cost to install.
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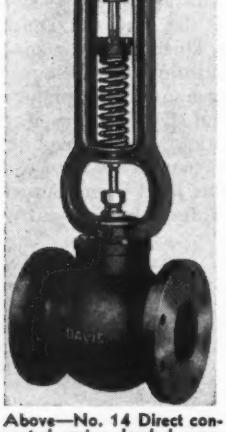
to *Simplify* the selection of Pressure Regulators...

	FOR STEAM, AIR AND GAS *ALSO RECOMMENDED FOR WATER AND OIL												FOR WATER			FOR GAS	
REGULATOR No.	2*	8	13	14*	15	16*	18*	19*	26*	27*	40	49*	408*	17	21	48	9	29
MAXIMUM INITIAL PRESSURE	600	1500	600	600	250	600	250	250	125	125	600	1500	1500	250	125	600	250	250
MINIMUM REDUCED PRESSURE	1	0	½	0	0	0	1	1	1	1	1	0	1	0	½	10	½	¼
MAXIMUM REDUCED PRESSURE	125	300	100	200	30	125	1	1	1	15	300	100	900	100	60	200	100	100
FOR DEAD END SERVICE			✔				✔	✔	✔		✔	✔			✔	✔		
DIAPHRAGM ACTUATED—Direct Acting	✔		✔	✔	✔	✔	✔	✔	✔	✔					✔		✔	✔
PISTON ACTUATED—Direct Acting		✔									✔	✔	✔	✔		✔		
AUXILIARY PILOT CONTROL								✔	✔	✔	✔	✔			✔	✔		
SPRING LOADED			✔	✔										✔			✔	✔
WEIGHT LOADED	✔	✔			✔	✔	✔				✔		✔	✔	✔	✔	✔	✔
SERVICE: GENERAL SERVICE	✔	✔		✔	✔	✔												
SERVICE: LOW PRESSURES—Heating	✔		✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔				✔	✔
SERVICE: HEAVY LOAD DEMANDS		✔			✔	✔					✔	✔	✔					
SERVICE: SPECIAL SERVICE		✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔			✔	✔
RANGE OF SIZES	½ to 6	4 to 24	½ to 2	½ to 24	½ to 24	½ to 24	½ to 24	½ to 24	½ to 24	½ to 2	½ to 12	½ to 12	½ to 12	2 to 6	½ to 2	2 to 24	½ to 24	½ to 24

...consult

DAVIS



Above—No. 14 Direct connected spring loaded regulator. For steam, air, gas, water, oil. For pressures to 400 psi. For reduced pressures 0 to 200 lbs.

Above—No. 40 or heavy duty, variable load conditions. Unaffected by high pressure fluctuations. Self-contained. Pilot operated. For pressures to 400 psi.

The variables encountered in the application of pressure regulators are so numerous that they make selection of the proper regulator a tough job at best. Yet, because choice of the proper types of regulator determines to such a very great extent the efficiency of the installation, it is essential that the job of selection is not slighted. To help you choose the proper regulator, Davis offers a number of helps:

1. A truly *complete* line of regulators to meet nearly every conceivable requirement. 18 different types for steam, air, gas, water, oil. Sizes to 24". For pressures to 1500 lbs.

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3. Engineering consultation on regulator problems.

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Attend the 1944 National Power Show

FOR NEW IDEAS

on production . . .
operation . . . maintenance

Engineers and executives interested in the conservation and use of power can find help on up-to-the-minute methods and operating data, as well as new developments and new products at the coming 16th National Exposition of Power and Mechanical Engineering. There, a display of tested, practical ideas, will help develop the more effective utilization of the Nation's power resources.

Engineering specialists in attendance at the numerous carefully-planned exhibits will give competent advice on the use and maintenance of products for use in the operation and maintenance of power plants. A display of tools for various power plant uses, will also be featured.

If you're thinking of tomorrow—
as well as today—

This year's event will be keyed to the effective solution of continuing war production problems, particularly those caused by sudden shifts in military needs. At the same time, it will also provide informational sources for the advancement of your planning for the period of peace ahead.

You will obtain a first-hand response to your war and peacetime thinking at this show by seeing new products in operation—many of them for the first time. Here will be up-to-date information on power plant applications—products of wartime development and improvement. The 1944 Power Show is an opportunity for you to crystallize your thinking and planning for tomorrow, as well as today.

Plan to attend with as many of your associates as can be benefited. As in the past, the Exposition will be open by invitation and registration to visitors directly associated with power and production operations, but closed to the general public. No admission fee will be charged.

REVIEW OF NEW BOOKS

Any of the books reviewed on these pages may be secured through Combustion Publishing Company, Inc., 200 Madison Ave., N. Y.

A.S.T.M. Standards on Coal and Coke

The September 1944 edition of the compilation of A.S.T.M. Standards on Coal and Coke includes five specifications, twenty-four methods of testing and evaluation, and six definitions. A major portion of the standards relates to coal, with standard methods covering sampling and analysis, fineness (powdered coal), grindability, etc.; for coke, tests include drop shatter, sieve analysis, etc. Specifications include widely used standards covering classification of coals by rank and by grade, sieves for testing purposes, and requirements on gas and coking coals.

As in many materials fields, standard definitions are extremely important, and through the work of A.S.T.M. Committee D-5 on Coal and Coke which sponsors the publication, definitions have been developed on terms relating to coal and coke, gross calorific value and net calorific value of fuels, and commercial varieties of bituminous and sub-bituminous coals. A proposed test not yet officially promulgated covers determination of agglutinating value.

The book comprises 132 pages, size 6 × 9, and is bound in heavy paper covers. Price $1.50.

Chemical Engineering Thermodynamics

By Barnett F. Dodge

Mechanical engineers as well as chemical engineers should find this work a useful reference for attacking problems in thermodynamics that always arise from time to time. Here will be found means to save effort and time though some of the problems are possibly a little strange to the average mechanical engineer's customary field.

The book does not presuppose a wide knowledge of thermodynamics but approaches the subject by first defining and developing the essentials of the first two laws. This is followed in subsequent chapters by applying these laws to the operations and processes with which the engineer is concerned. The manner in which this has been accomplished will be found unusually simple and lucid, especially in the transition from one step to the next. The generous sprinkling of practical problems with their complete numerical step-by-step solutions will be thoroughly appreciated.

The author is Professor of Chemical Engineering at Yale University and his wide background is closely woven into his subject matter. This volume well merits its place in the publisher's Chemical Engineering Series.

The book contains thirteen chapters: Definitions and Fundamental Concepts, The first Two Fundamental Laws, Quantitative Development of the Two Fundamental Laws and The Thermodynamic Functions, General Equations of Equilibrium, Pressure-Volume-Temperature Relations of Fluids, Thermodynamic Properties of Fluids, Compression and Expansion of Fluids, Thermodynamics of Fluid Flow, Heat Transfer, Refrigeration, Chemical Reaction Equilibrium, Vaporization and Condensation Equilibria, and Distillation Processes, together with an Appendix of useful constants and a broad Index of subjects and authors. It contains 680 pages, sizes $5^{5}/_{8} \times 8^{3}/_{4}$, 180 illustrations, and is bound in olive buckram. The price is $6.00.

Engineering Papers—Fourth Annual Contest

Sponsored by Hydraulic Institute

This publication is the outgrowth of the Hydraulic Institute's contests, held annually since 1940, to stimulate interest in problems of the pump industry and to encourage the employees of its members to contribute something of value in theory, design or practical application of pumps.

The five papers selected for inclusion in this typescript publication are: "Special Operating Conditions of Centrifugal Pumps," by A. J. Stepanoff; "A Common Language for Hydraulic Engineers," by Charles J. Tullo; "Critical Speeds," by Alexander Brkich; "Direct Acting Steam Pumps—Suggestions to make present pumping equipment meet wartime production requirements," by Darwin F. Schaub; and "Effect of Entrained or Dissolved Gas on Rotary Pump Performance," by Morgan B. Sennet.

The book contains more than 200 pages and is illustrated with many line drawings and charts. Bound in heavy paper covers. Price $1.50 plus postage.

Manual of Instructions on Proper Firing Methods

Issued by The Smoke Prevention Association of America, Inc.

This "Manual of Instructions on Proper Firing Methods" is published for the benefit of the coal dealer and the coal consumer in the interest of better fuel combustion and conservation, smoke abatement, and the minimizing of air pollution. It contains eleven authoritative chapters (some illustrated) covering such topics as: Preventing Spontaneous Combustion inStored Coal; How to Reduce Smoke from Hand-Fired Furnaces; The Service Engineer; Underfeed Stokers; Practical Applications of Statistical Methods for Controlling Coal Quality; Overfire Air Performance Applied to Stationary Plants; The Modern Spreader Stoker; Chain-Grate Stokers; Domestic Heating with Coke; Directions for Hand-Firing Coke; and Coal Must Serve to Be Conserved.

The Manual is in typescript form and the publishing cost has been met by the sale of advertising space. It is distributed by the Smoke Prevention Association of America, Inc., 139 North Clark Street, Chicago 2, Ill., on a complimentary basis to coal dealers and consumers on request when accompanied by postage (25 cents each) to cover the cost of mailing.

Rules for Fusion Welding Piping in Marine Construction

First published in 1938 by the American Welding Society, this standard has now been revised to bring the original data for welding low-carbon steel (0.35 per cent max.) marine piping up to date. Among the topics included are: Qualification of Welding Procedure; Qualification of Welding Operators; Design; Layout and Dimensions of Piping; Allowable Types of Joint; Preheating; Stress-Relieving; Radiographic Tests; and Hydrostatic Tests.

Copies of the standard are available in the form of a 4-page 6 × 9 bulletin at a price of 25c per copy.

Seamless Steel Tube Data

Compiled by Seamless Steel Tube Institute

The material in this 320-page loose-leaf Tube Data book was assembled and published by the Seamless Steel Tube Institute as a service to manufacturers and users of equipment employing carbon-steel and alloy tubing. It contains four main sections covering General Data, Mechanical Tubing, Pressure Tubing and Reference Tables and comprises the most useful collection of seamless steel tube data that has appeared in one volume.

Under General Data there is a brief summary on the history, manufacture, tests, special shapes and standard steels with particulars of chemical composition, mill practices, etc. The section on Mechanical Tubing covers information on typical uses, how to obtain best results through the use of tubing, determining proper size, with complete tolerance tables, properties for beams, and a digest of standard specifications.

The section on Pressure Tubing covers various pressure formulas, specifications and tolerance tables for boiler tubes, heat-exchanger and condenser tubing, still tubes, alloy steel pipe, stainless steel analyses, with metallurgical data. The Reference Table section is unusually extensive with many formulas, weight tables for rounds, squares, rectangles, surface areas both inside and outside, and other tables commonly found useful in tubing applications.

The Seamless Steel Tube Institute is to be congratulated in undertaking this work. The typography is excellent. The book also contains a Glossary and an Index and provision is made in the loose-leaf binder for the addition of supplementary sheets with new data which will be supplied from time to time. The page size is $8^{1}/_{2} \times 11$. Price $2.50.

RODA — High grade gas, by-product and steam coal from Wise County, Va., on the Interstate Railroad.

BENDRON — High grade gas, by-product, steam and domestic coal from Wise County, Va., on the Interstate Railroad.

STONEGA — High grade, high volatile steam and by-product coal from Wise County, Va., on the Interstate Railroad.

PREMIX STOKER — A laboratory controlled product blended to meet exacting stoker requirements. From Wise County, Va., on the Interstate Railroad.

COKE — Roda and Stonega from Wise County, Va., and Connellsville Coke from Pennsylvania.

Our personnel with the experience gained through long and varied marketing activity assures effective servicing of any fuel requirement.

CRITERION COAL — High grade gas, by-product, steam and domestic coal—Pittsburgh seam from Irwin Basin, Westmoreland County, Pennsylvania, on the Penna. Railroad.

CROZER — Genuine Third Vein Pocahontas from McDowell County, W. Va., on the Norfolk & Western Railroad.

Admiralty Coal — Genuine New River Smokeless, Beckley or Sewell seam from Raleigh County, W. Va., C. & O. and Virginian Railroads.

Old Kentucky — Hazard No. 4 and No. 7 steam and domestic coal from Wiscoal, Knott County, Kentucky, on the L. & N. Railroad.

GENCO — Steam and domestic coals from a number of producing districts.

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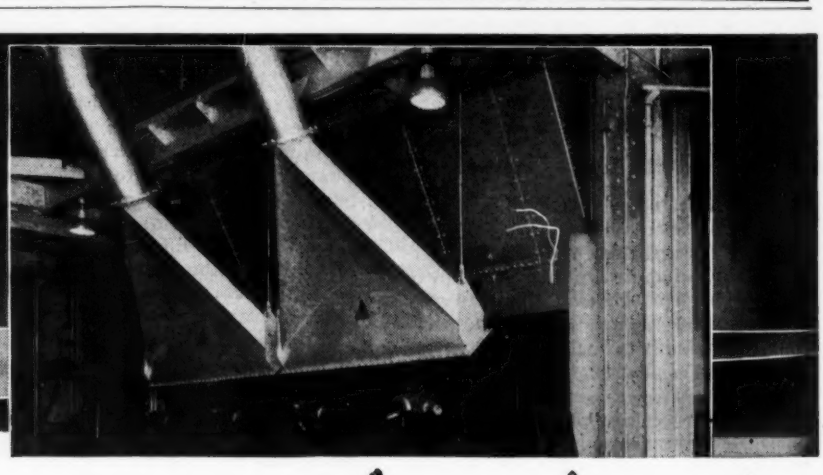
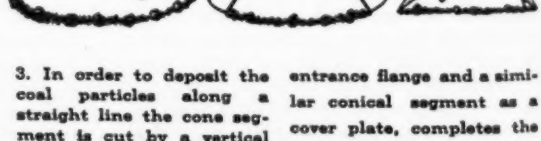
We know why CONICAL distributors won't segregate coarse and fine coal—but, do YOU?



● Segregation leads among the enemies of efficient combustion . . . and with this in mind STOCK Engineering Company developed the CONICAL Non-Segregating Coal Distributor, designed to deliver a uniform mixture of coarse and fine coal across stoker hoppers. Highly successful operation-results in hundreds of plant installations have proved that the CONICAL Distributor *will* eliminate segregation, insure complete combustion, increase CO_2 percentage and increase fuel burning capacity of stokers.

For a clearer understanding of the principles of CONICAL Distribution look over the diagrams at the right. As you read compare the CONICAL Distributor with flat-chute distribution methods and results.



1. If a number of pieces of coal are placed at the apex of a cone, the axis of which is vertical, and then released, they will slide down any element of the cone.

2. A segment of a cone will produce the same result. The flow of coal particles is parallel—and this plus the cone shape produces a uniform distribution.

3. In order to deposit the coal particles along a straight line the cone segment is cut by a vertical plate, as in Fig. 3. The addition of two side plates, an entrance flange and a similar conical segment as a cover plate, completes the CONICAL Non-Segregating Coal Distributor.

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A FREE BOOKLET, illustrating and explaining further advantages of the CONICAL Non-Segregating Coal Distributor will be sent at your request. Address inquiries to Stock Engineering Co., 713 Hanna Bldg., Cleveland 15, Ohio.

CONICAL Non-Segregating Coal Distributors **S.E.Co. Coal Valves and Coal Scales**

Joint A.S.M.E.-A.I.M.E. Fuels Meeting Program

For the past seven years the Fuels Division of the American Society of Mechanical Engineers and the Coal Division of the American Institute of Mining and Metallurgical Engineers have held annual Joint Fuels Conferences. At these meetings, which were national in scope, problems of mutual interest in the production and utilization of coal were dealt with. This year, because of the transportation situation, the conference which is to be held at Charleston, W. Va., has been designated as a local meeting with the West Virginia Section, A.S.M.E. and the Central Appalachian Section, A.I.M.E. participating. However, much of the program is not restricted to local problems.

The Conference is scheduled for October 30 to 31, inclusive, with headquarters at the Daniel Boone Hotel and technical sessions at the Beni Kedem Shrine Temple. The program is in part as follows:

Sunday, Oct. 29

2 p.m.—Registration open

Monday, Oct. 30

9 a.m.—Address of welcome by C. C. Dickinson, president of the Dickinson Fuel Company, and a response by E. G. Bailey, representing R. M. Gates, president of the A.S.M.E.

10:15 a.m.

"Industrial Coal Requirements of the Kanawha Valley," by W. T. Harris, Jr.

"The National Fuel Efficiency Program," by T. C. Cheasley

12:30 p.m.—Luncheon Meeting

Speaker, Philip Sporn, executive vice president, American Gas & Electric Service Corporation

2 p.m.

"Coal Facts, Coal Characteristics and Imagineering with Underfeed Stoker Fuel Beds," by L. A. Shipman

"Design of Small Steam Plants," by H. C. Carroll

"Use of Anthracite Fines for By-product Coking," by J. C. Clendinin, K. M. Barclay and C. C. Wright

4:30 to 6 p.m.

Committee meetings

6:30 p.m.

Informal Dinner

8 p.m.

Inspection trips to Synthetic Rubber Plant of U. S. Rubber Co., and the Cabin Creek Power Plant of the Appalachian Electric Power Co.

Tuesday Oct. 31

9:45 a.m.

"Forms of Sulphur in Coal and Their Origin," by W. T. Brown

"Variable Seam Conditions Encountered in Mechanical Mining and How They Are Met," by W. W. Beddon

"Tipple Problems Under Mechanical Mining," by E. C. Carris

2 p.m.

"Blending Coals for Better Product Control," by R. F. Stilwell

"The Missing Data on Coal Sampling," by B. A. Landry

6:30 p.m.

Annual Banquet, H. G. Kennedy, Toastmaster

Presentation of Percy Nicholls award to J. B. Morrow of Pittsburgh Coal Co. and address by S. H. Haughton on "Fuel in South Africa."

Shipment of Mobile Power Plants

The photograph shows one of several shipments of mobile power plants now in the hands of Soviet Russia. Forty of these particular plants, rated at 3000 kw and consisting of locomotive-type boilers furnishing steam to G. E. turbines are being supplied to provide power in Axis-devastated areas as they are retaken by the Allied armies. These are in addition to a large number of 1000- and 5000-kw plants of different design and make which have been previously described in these pages.

Boiler car being loaded on ship for transport to Russia

Each of the plants here shown is made up of ten cars constituting a complete power-generating unit. After being hauled to the power-needy sites behind the fighting lines, they can be put into operation within a day, as they require only a supply of coal and water to complete the required facilities for the ready supply of electrical energy.

New Post-graduate Course

The training department of the Allis-Chalmers Manufacturing Co., in cooperation with the Illinois Institute of Technology, has launched a new post-graduate educational course which will lead to a Master of Science degree in electrical or mechanical engineering.

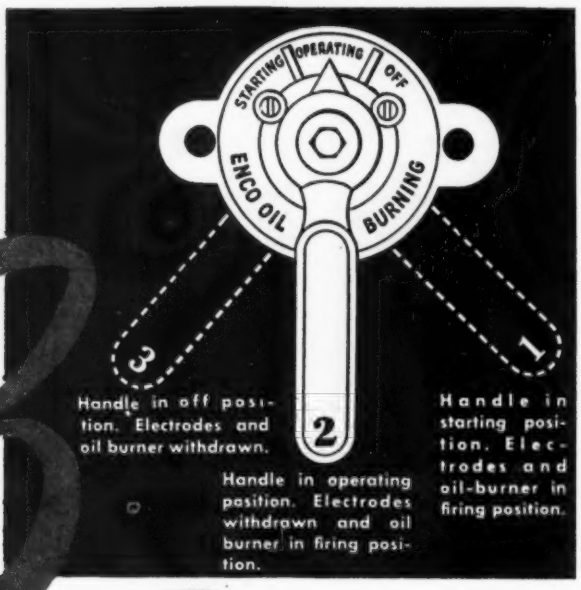
The graduate course of instruction, conducted after working hours, will be taught at the West Allis plant by professors of the Illinois Institute of Technology. The Master of Science degree will be granted to graduate engineers after the completion of 32 hr of the approved curriculum, with a grade of "B" or better, and the writing of a satisfactory thesis. While the course will be open to any company employee with sufficient background to handle the studies, the post-graduate degree will depend upon approval of undergraduate work.

Annual Water Conference

A two-day meeting has been announced for the Fifth Annual Water Conference to be held at the William Penn Hotel, Pittsburgh, on October 30 and 31, under the sponsorship of the Engineers' Society of Western Pennsylvania. The program consists of twelve papers on the treatment of boiler and industrial waters and each will be followed by five-minute prepared discussions. In all, about sixty such discussions have been scheduled.

Of particular interest to power engineers will be the papers on "Two Zone Methods of Operating Hydrogen Exchangers for Boiler Feedwater," by M. J. Shoemaker; "Recent Experiences in Demineralizing Water," by M. E. Gilwood; "Removal of Ammonia by Chlorination," by A. E. Griffin; "Once Through and Recirculating Cooling Water Studies," by Dr. H. L. Kohler; "Cathodic Protection of Steel Submerged in Water, by L. P. Sudrabin; and "Water Treatment at Koppers United Company Plant, Kobuta, Pa.—Filtration, Softening and Boiler Feed Treatment," by Paul J. Stein.

Hand Control Valve for cylinders . . . wall mounting . . . oil burner ignition system.



3 Step IGNITION SYSTEM FOR PULVERIZED COAL, OIL, OR GAS

FAST SAFE POSITIVE

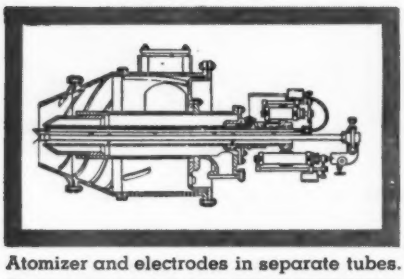
With an Enco Ignition System, operator can light off any burner by movement of a Hand Control Valve, located close to the pulverized-coal mill and fan controls, and within view of the instrument board. Automatically, a powerful ignition spark is established, and the light fuel turned on. Both are interlocked electrically— **the oil valve cannot be opened until the spark current is on and the atomizer is in firing position.** After the oil flame is established, a second movement of the control valve retracts the electrodes, leaving the atomizer in operation.

After ignition of the pulverized coal is established, a third movement of the control valve shuts off the oil and retracts the atomizer out of the hot zone, leaving the unit ready to repeat the operation as may be needed.

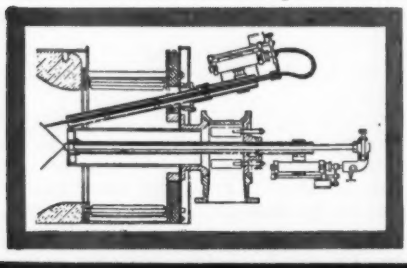
The Enco Ignition System has a wide range of application. Pulverized coal, blast furnace gas or any liquid fuel may be ignited by the unit, or the spark alone may be used to ignite natural or refinery gas. The ignition flame can be changed gradually from light to heavy fuel oil if continued operation under heavy load is required. The ignition flame also can be used as a substitute for principal fuel in emergencies.

Bulletin on request.

Atomizer and electrodes in the central tube.



Atomizer and electrodes in separate tubes.



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Enco OIL BURNING EQUIPMENT

Electric Power for August

As reported by the Federal Power Commission, electric energy produced for public use in August 1944 totaled 19,513,245,000 kwhr, which represented an increase of 3 per cent over that of August 1943. For the twelve months ending August 31, 1944, the total production was 228,655,210,000 kwhr, or an increase of 10.7 per cent over the corresponding period ending August 31, 1943. Of that produced in August 1944, 29.5 per cent was supplied by water power.

Peak demands for August of this year exceeded by 3.7 per cent those for the same month last year.

Coal consumption amounted to 7,044,034 tons of bituminous and 321,530 tons of anthracite, which were, respectively, 9.8 and 8.4 per cent in excess of July. Fuel oil consumed, amounted to 1,504,660 bbl which represented a decrease of 1.7 per cent from that of July. On the other hand, gas consumption increased 3.3 per cent.

The total capacity of generating plants in electric utility service, as of August 31, 1944, was 50,122,121 kw which represented a net increase of 129,016 kw during the month.

Warren D. Lewis Becomes President of N.A.P.E.

At its recent Annual Convention in St. Louis, the National Association of Power Engineers elected Warren D. Lewis president for the ensuing year.

Mr. Lewis, who is chief engineer and building superintendent of the Hotel New Yorker, has long been an active member of the N.A.P.E. in both local and national affairs and has taken a leading role in its educational work. Among the numerous offices which he has held from time to time were president of the Brooklyn Association No. 8, president of the New York State Association and vice president of the national body.

A graduate of Pratt Institute, Brooklyn, in mechanical and electrical engineering, he held positions successively with the motive power department of the New York Central Railroad, the Brooklyn Edison Company and as assistant chief engineer of the Metropolitan Life Insurance Building, before becoming chief engineer of the Hotel New Yorker. While serving in that capacity, he was also at one time engineering consultant for the National Hotel Management group having engineering supervision over a number of hotels in various cities.

Besides his affiliation with the N.A.P.E. Mr. Lewis is a member of the American Society of Mechanical Engineers and a registered professional engineer in both New York and New Jersey.

At the St. Louis convention other officers of the N.A.P.E. elected for the 1944–45 term were A. E. Wills of Kansas City, Mo., vice president; A. F. Thompson, Chicago, secretary; Harry J. Harp, Manchester, N. H., treasurer; C. E. Exbom, Chicago, conductor; and Eugene Bishop, St. Louis, doorkeeper.

NEW CATALOGS AND BULLETINS

Any of these publications will be sent on request

Carbonaceous Zeolites

Cochrane Reprint No. 32 is descriptive of some important theoretical considerations demonstrating characteristics of acid regenerated carbonaceous zeolites. The article summarizes extensive research work when using sulphuric acid as the regenerant and shows the characteristics of various salts, singly and in combination. A paper that is of interest to anyone interested in the theoretical considerations of this unique method of water conditioning, or to those interested in the purchase of this type equipment for boiler feed or process requirements.

Cleaning Turbines

The Shell Oil Company has issued a 16-page "Turbine Cleaning Manual" which describes a new technique for the solvent cleaning of turbines by the use of Shell Turbo Cleaner. This oil-type cleaner has good dehydrating properties and high solvency for oil deterioration products. It is not expected to remove tightly bound rust, but it does remove loose rust, sludge, lacquers and other contaminants.

Conduit Systems

The Ric-wiL Company has issued a 12-page catalog (No. 44) covering its conduit systems for underground and overhead steam, oil or hot water lines. The bulletin is copiously illustrated and contains capacity tables, trench dimensions and general specifications for Ric-wiL prefabricated insulated pipe units and for tile or cast iron conduit systems.

Decarbonators

Cochrane Corporation publication 2975 is a 4-page folder descriptive of Cochrane Decarbonators for removing certain dissolved gases from water solution. Applications include the removal of carbon dioxide in connection with iron removal plants and the degasification of hydrogen zeolite softened waters.

Flat Spray Nozzles

Chain Belt Company has issued a new 8-page bulletin (No. 459) descriptive of REX Flat Spray Nozzles. These nozzles are for service in all industries where water is used for cleaning, cooling and washing operations. The bulletin is profusely illustrated and gives tabular information concerning nozzle size, dimensions, discharge in gallons per minute; also a list of materials, sizes and prices.

Flow Measurement

"Builders Shuntflo Meters for Steam, Air, Gas" is the title of an 8-page bulletin (No. 349) issued by Builders-Providence, Inc. The features of Shuntflo meters are described and admirably illustrated in this bulletin and capacity tables are given for sizes ranging from 1 to 12 inches.

Hydraulic Handbook

The Aldrich Pump Company has issued an attractive 60-page "Aldrich Hydraulic Handbook" (Bulletin 50). It contains complete and authoritative hydraulic information and tables, under the following headings—Water Head Equivalents, Pump Plunger Loads, Hydraulic Formulae, Plunger Displacement, Pressure Equivalents, Capacity of Shafts, Electrical Data, Pump Discharge Diagrams, Accumulator Volumes, Friction Losses in Fittings and Pipes, Capacities of Pumps and Cylinders, Barometric Pressures, Pipe Data, etc. The second section of the handbook is devoted to Aldrich manufacturing facilities and the third is a condensed catalog of Aldrich pumps and hydraulic equipment. Many high-pressure triplex and quintuplex pumps, for usual and unusual services in the marine, power, petroleum and other industrial fields are illustrated and described.

Mechanical Drive Turbines

Elliott mechanical drive turbines, type CY, with built-in vertically offset reduction gearing, are described in a new 4-page bulletin (H-15) issued by Elliott Company. The text is illustrated with line drawings and photographic halftones.

Open Steel Grating

Wm. F. Klemp Company has issued a 24-page booklet giving latest information on its open steel grating and stair treads. The bulletin is profusely illustrated with halftones and diagrams and gives full installation data for riveted and welded types of grating. A typical layout diagram and a safe load table are also given.

Pop Safety Valves

J. E. Lonergan Company has issued an 8-page bulletin (501-A) featuring its line of iron, steel and bronze pop safety valve constructions adopted in accordance with Simplified Practice Recommendations R-201-43 and R204-44 of the National Bureau of Standards. Tables I, II and III summarize the sizes, connections, service limits and other standard specifications set up for each type of valve. Illustrations include photographic halftones and "blueprint" sectional views.

Safety Valves

Manning, Maxwell & Moore, Inc., has just published a new Consolidated Safety and Safety Relief Valve catalog covering the entire Consolidated line of Valves for all industries.

All valves are illustrated, scope of design is given together with parts and materials, dimensions and other general information such as capacity tables, sizing charts, selection charts, etc.

Miniature editions of the catalog are being prepared, and will be available to users of Safety or Safety Relief Valves when it comes from the press.

Valves

Slide valves and butterfly valves for the control of air, gas and liquids are covered in a new 24-page catalog issued by W. S. Rockwell Company. The slide valves range in sizes from 1 to 20 in. and the butterfly valves up to 48 in. They are of the lever, hand-wheel and chain-wheel control types. Complete tables of dimensions are included for all types and sizes as is also an air discharge chart.

V-Belt Drives

A new 44-page handbook on industrial fractional horsepower V-belt drives has just been published by The B. F. Goodrich Company. The booklet notes the trend toward larger sheaves in both fractional horsepower and multiple V-belt drives, describes the construction of fractional horsepower V-belts and gives prices and data on both sheaves and belts. There is a chapter on proper selection of FHP belt drives, with formulas, together with a page on how to get the most service from V-belt drives. Horsepower ratings and general engineering data of these drives are given, together with selection tables of stock drives using pressed steel and cast iron FHP single groove sheaves and adjustable cast iron single groove sheaves. Twenty-seven pages are devoted to these tables.

Worm Gear Speed Reducers

"A Complete Data Book on Worm Gear Speed Reducers for Industrial Applications" is the title of a new 100-page book (No. 1824) announced by the Link-Belt Company. The book is replete with photographs, dimensional line drawings, engineering data, horsepower ratings, and tables of weights and dimensions all aimed to help in selecting the type and size of reducer required for a specific service. Three interesting examples are worked out to show more specifically how to use the data given.

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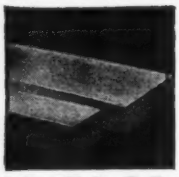

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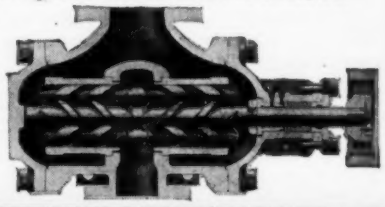

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